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ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS

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RADIATION PROTECTION - 1975

ANNUAL EPA REVIEW OF RADIATION PROTECTION ACTIVITIES

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
WASHINGTON, D.C. 20460

JUNE 1976

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FOREWORD

An EPA presentation, "Radiation Protection Activities – 1974 (a prototype for subsequent annual reports)," was published in September 1975. This report was developed with limited input and coordination from other Federal and State agencies. The first annual report was developed by EPA to provide a summary of major events, issues, and progress in radiation protection in the United States, as well as a discussion of the underlying issues and problems accompanying them.

The EPA, under its Federal Guidance authorities, is responsible for advising the President on all matters pertaining to radiation and, through this mechanism, to provide guidance to other Federal agencies on radiation protection matters.

This report presents highlights of significant radiation protection activities of all Federal agencies which were completed in 1975, or in which noteworthy progress was made during that period, and those events affecting members of the public. State or local activities are also presented where the effects of those events may be more far-reaching. The report will be made available to Congress, key administrative officials, Federal agencies, States and the public. Federal agencies with radiation protection activities and responsibilities for protecting the public health have contributed summary material for inclusion in the report. Even though each agency prepares an annual report on its activities, there is no single source that sets forth the overall efforts of the Federal government in radiation protection.

At the Federal level significant strides have been made in reducing unnecessary radiation exposure through the efforts of the responsible agencies. These efforts have resulted in the promulgation of certain standards, criteria and guides. Improved control technologies in many areas make it feasible to reduce emissions at a reasonable cost to levels below current standards and guides. This report provides information on the significant activities leading to the establishment of the necessary controls for protection of public health and the environment. Such controls are developed through due process, including public participation. Particularly significant are the discussions of several major problems in the development of nuclear energy in the public forum through the National Environmental Policy Act process in the form of the Environmental Impact Statements (EIS's). Equally as important are radiation protection activities in other areas such as medical, occupational and consumer product radiation, where actions have been taken to minimize unnecessary radiation exposure. In the context of radiation protection, ancillary activities are included in this report in order to present a comprehensive overview of the events that took place in 1975 that could have an effect on public health, either directly or indirectly. Because of the restraints in developing this type of report, it is not possible to include detailed information on a particular activity.

Reports of routine or continuing radiation protection operations may be found in publications of the sponsoring Federal agencies, as can more detailed information about activities reported in this document. Appendix B lists some of these reports.

Office of Radiation Programs technical reports are distributed to State and local radiological health offices, Office of Radiation Programs technical and advisory committees, universities, laboratories, schools, the press, and other interested groups and individuals. These reports are also included in the collection of the Library of Congress and the National Technical Information Service.

I encourage readers of these reports to inform the Office of Radiation Programs of any omissions or errors. Your additional comments or requests for further information are also solicited.

W. D. Rowe

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs

EXECUTIVE SUMMARY – CHAPTER 1

Nuclear reactors now produce about 8.3 percent of the Nation's electrical power. By the end of 1975 there were in the U.S. nuclear power industry 56 plants with operating licenses, 69 plants with construction permits, 90 plants on order, and 21 plants firmly planned for a total of 236 commitments. These figures reflect the existing importance of nuclear power to the United States. This, coupled with expectation of increasing reliance on nuclear energy in the future, has accounted for much concern over radiation hazards and consequent protection activities. This concern has been expressed by both public and private sectors alike. Private concern has manifested itself in part as citizen participation in hearings on nuclear energy environmental impact statements and criteria and standards development. At the Federal level, concern for radiation control has taken the form of continuing research and monitoring efforts in order to establish a data base upon which subsequent revision and promulgation of standards might be based.

In addition to its activities aimed at potential radiation hazards from nuclear power plants, the Federal Government has initiated radiation protection programs aimed at many other potentialally hazardous radiation sources. Increased mining, processing, and transport of radioactive materials, expanded medical applications of diathermy, lasers, x-rays, and radionuclides for therapeutic and diagnostic purposes, x-rays, radionuclides, and lasers for testing and quality control in industry, and increased use of radio and microwave transmitters, televisions, radar, and radios have all prompted Federal activity in regard to radiation protection.

The following are highlights of Federal radiation protection activities identified for 1975:

- The Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC) became effective January 19, 1975. They were established by Executive Order 11834, signed by the President on January 15, 1975, in fulfillment of the passage by Congress of Public Law 94–438, "The Energy Reorganization Act of 1974."

- In May, the Nuclear Regulatory Commission forwarded to the Congress a legislative proposal to improve the licensing process for major nuclear facilities, which was introduced as S. 1717 and H.R. 7002.

- The President, on December 31, 1975, signed a bill to extend and modify the Price-Anderson Act. The modification involved a provision for replacing the Government indemnity designed to protect nuclear power plant licensees in the unlikely event of a nuclear catastrophe with a retrospective premium insurance system over a period of years as more power reactors become licensed. Price-Anderson coverage would also be extended to cover offshore nuclear power plants and shipments of nuclear material between NRC licensees via routes wholly or partially outside U.S. territorial limits.

- During the 94th Congress, First Session, the Joint Committee on Atomic Energy (JCAE) held public hearings directly related to radiation protection problem areas. On March 19, 1975, a subcommittee under the chairmanship of Representative Mike McCormack reviewed the Liquid Metal Fast Breeder Reactor (LMFBR) and related activities of ERDA. Throughout June and July, testimony was heard from Government agencies, industry, and private citizens on both sides of the issue relevant to the need for the Breeder program.

- On February 5, 1975, the JCAE held a hearing on the NRC action of January 30, 1975 requiring the operators of 23 boiling water reactors to perform prompt safety inspections of certain piping in their plants.

- On October 29, 1975, the NRC transmitted to the JCAE the final report of the Reactor Safety Study, referred to as the Rasmussen Report.

- On November 19, 1975, the JCAE held a public hearing on the policies, plans, and programs of the Executive Branch to provide for the safe storage and disposal of radioactive wastes produced in the commercial nuclear fuel cycle.

- Section 274 of the Atomic Energy Act authorizes the Nuclear Regulatory Commission to enter into agreements with States whereby they assume regulatory authority over certain radioactive materials. At the end of 1975, there were 25 Agreement States exercising regulatory jurisdiction over a total of approximately 10,500 nuclear material licenses.

- On January 23, 1976, the U.S. Nuclear Regulatory Commission published in its "Information Report on State Legislation" a summary of laws affecting nuclear power plants which were enacted by the States during the 1975 legislative session.

- During 1975 the National Council on Radiation Protection and Measurements (NCRP) published four reports; Report No. 43 entitled "Review of the Current State of Radiation Protection Philosophy," Report No. 44 entitled "Krypton-85 in the Atmosphere – Accumulation, Biological Significance, and Control Technology," Report No. 45 entitled "Natural Background Radiation in the United States," and Report No. 46 entitled "Alpha-Emitting Particles in Lungs."

- During 1975 the Health Physics Society, in conjunction with its Standards Committee, assumed the responsibility of the Secretariat for the American National Standards Institute (ANSI) of its Main Committee N-13 "Radiation Protection." Under this program there are 15 scientific groups actively involved in the development of standards. Approximately 610 nuclear standards are in various stages of development or are in the publication process by ANSI.

- On April 30, the Nuclear Regulatory Commission (NRC) announced a significant new regulation, effective on June 4, 1975, which provided definitive numerical guidance to NRC licensees on how to comply with the previously enunciated requirement that levels of radioactive material in effluents from light-water-cooled power reactors and resultant doses to the public be kept "as low as reasonably achievable."

- The EPA published in the *Federal Register* on May 29, 1975, a notice of rulemaking for the Uranium Fuel Cycle designed to provide environmental and public health protection. These standards would limit quantities of long-lived radioactive materials in the general environment attributable to planned releases from operations contributing to the generation of electric power through the uranium fuel cycle.

- During 1975 the Nuclear Regulatory Commission (NRC) issued for comment 13 draft environmental impact statements (EIS's) and 16 final EIS's on conventional nuclear power plants. The Environmental Protection Agency (EPA) reviewed and commented on each of the draft statements.

- Offshore Power Systems, Inc. applied in 1973 to the Atomic Energy Commission for a license to manufacture eight floating nuclear power plants. The final EIS (Part 1) was issued in October 1975. This part pertained to the environmental aspects of the manufacturing facility at Blount Island, near Jacksonville, Florida. A second part, pertaining to the generic aspects of siting and operation of floating nuclear power plants on the Atlantic and Gulf Coasts, was issued in December 1975.

- A draft EIS for the Light Water Breeder Reactor (LWBR) was issued for comment by ERDA on August 8, 1975. The statement addressed LWBR technology development and specifically the demonstration program at the Shippingport reactor.

- In 1975, the NRC issued a revision to its Regulatory Guide on environmental radiation surveillance. The revised guide "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," provides the latest guidance on acceptable programs for monitoring radioactivity around nuclear power plants.

- The Office of Radiation Programs (ORP) of the EPA conducts field studies at operating nuclear facilities as a part of its dose assessment program. In 1975 report preparations were undertaken for completed studies at; the Oyster Creek Nuclear Power Plant at Toms River, New Jersey, the Quad Cities Nuclear Power Station at Cordova, Illinois, the Cooper Nuclear Station in Brownville, Nebraska, the Monticello Nuclear Generating Plant, the G.E. Fuel Fabrication Plant north of Wilmington, North Carolina, and Puget Sound Naval Shipyard in Bremerton, Washington. A study at the Browns Ferry Nuclear Power Plant in northern Alabama was initiated in July 1975.

- EPA's Office of Radiation Programs has initiated a dose assessment program. Part of the environmental radiation data gathered in this program is acquired from EPA's Environmental Radiation Ambient Monitoring System (ERAMS). A quarterly summary of raw data from ERAMS is reported in *Environmental Radiation Data*.

- ORP has initiated a project for evaluating the radiological quality of the environment annually as a part of the dose assessment program. Preparation of the first annual *Radiological Quality of the Environment* report was undertaken in 1975.

- An effort is underway by the EPA Monitoring Systems Research and Development Division's Quality Assurance Branch in Las Vegas to prepare standard reference materials which contain *in vivo* pollutants. Reference materials in preparation during 1975 include Uranium-235/-238 series, Thorium ore, Uranium mill tailings and Radium-bearing soil.

- The responsibilities of certain Federal Agencies with regard to radiological incident emergency response planning for fixed facilities and transportation, including provisions for planning assistance to State and local governments, were defined in a *Federal Register* notice initially issued in 1973 and revised in December 1975 by the Federal Preparedness Agency in the General Services Administration.

- The EPA has prepared a Manual of Protective Action Guides and Protective Actions for Nuclear Incidents. During 1975, EPA continued to study the relative benefits of shelter and evacuation as protective actions and the cost-risk-benefit of protective actions for exposure from deposited radioactive material.

- In November, the NRC revised its requirements for fuel cycle reporting. Semi-annual reports are to be required for effluents from uranium mills, uranium hexaflouride production facilities, and users of plutonium or enriched uranium for fuel fabrication, processing, or scrap recovery.

- Activities to meet the problems of radioactive waste disposal accelerated during 1975. ERDA has de-emphasized earlier plans to develop an interim retrievable surface storage facility and is concentrating on methods for long-term waste disposal. In November 1972, the United States signed the International Ocean Dumping Convention which was ratified in April 1974. The Convention thereby became a treaty to be entered into force in October 1975. In 1975, ERDA issued a report on the storage problems associated with spent fuel elements. ERDA also restarted a program leading to the construction of a pilot disposal facility in bedded salt in southeast New Mexico.

- EPA has funded efforts by State licensing agencies to perform annual inventories of quantities of waste materials received at the commercial burial sites. Efforts are currently underway to obtain the 1974 and 1975 inventory results.

- The International Atomic Energy Agency (IAEA) was charged with the responsibility to develop specific recommendations regarding ocean dumping of all radioactive wastes pursuant to the International Ocean Dumping Treaty (ratified in August 1975).

- The Administrator of the EPA approved a program request on July 5, 1974 to form an Interagency Working Group on Medical Radiation. During 1975, a subcommittee of this group, Subcommittee on Prescription of Exposure to X-Rays (SPEX), drafted a report on prescription diagnostic x-ray studies. The recommendations in this report, when endorsed by the Working Group, will be used by EPA as a basis to develop Federal Guidance for diagnostic radiology.

- In the 15 December 1975 issue of the *Federal Register*, the FDA announced plans to develop guidelines concerning exposure of women of childbearing age to ionizing radiation from medical diagnostic procedures.

- A revised "Suggested State Regulations for Control of Radiation," has been published and distributed to State radiation control agencies. A notice of availability of the Regulations was published in the *Federal Register* Vol. 40, Number 136, dated July 15, 1975.

- The FDA has proposed a group of 11 general amendments to the Federal Performance Standard for Diagnostic X-Ray Systems and their Major Components. The Notice of Proposed Rulemaking was published in the *Federal Register* on June 11, 1975.

- The Food and Drug Administration has proposed a guideline for the use of gonad shielding during medical diagnostic x-ray procedures. The proposal appeared in the *Federal Register*, September 16, 1975.

- During 1975, the Food and Drug Administration, in cooperation with the American College of Radiology and the West Virginia State Department of Health, field tested a diagnostic radiology quality assurance program for future implementation by State radiation control personnel.

- DENT is a program developed by FDA for use by State and local radiation control agencies in encouraging dentists to standardize dental x-ray machine exposures within established ranges that produce high quality x-ray films with acceptable patient exposures. During 1975, full-scale DENT programs were underway in 16 States, local subdivisions, and Federal agencies.

- Manufacturers are required by 21 CFR 1002.20 to report accidental radiation occurrences to the BRH. Six incidents were reported by manufacturers to the FDA's Bureau of Radiological Health during calendar year 1975 and were investigated to determine their causes. Nine incidents involving radiation exposure were reported to the Radiation Incidents Registry, BRH, from a variety of sources.

- The first extensive study to determine the impact of the uranium mining and milling industry on ground water quality was completed by EPA in August 1975 in the Grants Mineral Belt area of New Mexico.

- The Office of Radiation Programs Las Vegas Facility of the EPA conducted a sampling and analysis program for radioactivity in geothermal fluids in 1975.

- In 1975, the EPA-ORP involved itself in a variety of research, monitoring, and surveillance activities aimed at solving the problems associated with phosphate mining and milling. As part of its efforts, the EPA has established an interim guideline for new construction on land reclaimed from phosphate mining activities.

- During the past year, EPA has reviewed data concerning present levels of both natural and artificial radioactivity in drinking water supplies. Based on these data, proposed interim regulations for radioactivity in drinking water were published for comment in the *Federal Register* on August 14, 1975.

- On June 17, 1975, EPA awarded Harvard University School of Public Health a contract to study radiation exposure due to building materials.

- Using the Mobile Radiofrequency Measurements System, the EPA measured environmental levels of nonionizing radiation in Boston, Massachusetts (October 1975) and Atlanta, Georgia (December 1975).

- In 1975, 69 production or pre-production microwave ovens were laboratory tested and found to be in compliance with the Federal Performance Standard for Microwave Ovens. Compliance actions were taken against five manufacturers of microwave ovens.

- BRH has proposed an amended performance standard for the requirements for interlock concealment and prevention of object insertion into microwave ovens. The proposal appeared in the *Federal Register* on June 26, 1975.

- The International Atomic Energy Agency (IAEA) has completed the general plan for a comprehensive set of safety codes and guides for nuclear power plants.

- Launches of two identical spacecraft, Viking A and Viking B, were made during 1975. Each of these spacecraft contained 20,000 curies of plutonium in a Space Nuclear Power System (SNAP).

- During 1975, NRC published 4 draft EIS's and 2 final EIS's on non-conventional nuclear projects while ERDA issued 5 draft EIS's and 4 final EIS's. These EIS's concerned the following projects: Plutonium Powered Cardiac Pacemakers, the Barnwell Fuel Receiving and Storage Station, a Generic Site Evaluation on Off-Shore Power Systems Floating Nuclear Power Plants (FNPP), Licensing Exemption for Spark-Gap Irradiators Containing Cobalt-60, A High Temperature Gas-Cooled Reactor (HTGR), FNPP Manufacturing Facilities, The Tokamak Fusion Test Reactor, Expansion of U.S. Uranium Enrichment Capacity, FY 1976 Supplement to Underground Nuclear Testing, The Light Water Breeder Reactor (LWBR) Demonstration Project, and The U.S. Nuclear Export Program. Also, the AEC issued a proposed Final Statement on the Liquid Metal Fast Breeder Reactor Program in December 1974, and the Final Statement in December 1975.

LEGISLATION AND STANDARDS ACTIVITIES - CHAPTER 2

INTRODUCTION

During 1975 significant activities have taken place at the Federal level by the adoption of new legislation and by Congressional hearings on critical problems relating to radiation safety and protection of public health. States and non-Government groups have been active in publishing radiation protection standards. At the same time there continues to be increased public participation in the development of radiation controls at both the Federal and State levels through participation in various meetings and public hearings.

LEGISLATION

Energy Reorganization Act of 1974

On January 15, 1975, the President signed Executive Order 11834, which brought into being the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC) to be effective on January 19, 1975. The action was in fulfillment of the passage by Congress of Public Law 94–438 "Energy Reorganization Act of 1974," which the President signed on October 11, 1974. An interagency Energy Resource Council has also been established in the Executive Office of the President to insure coordination among the Federal agencies that have responsibilities for development and implementations of energy policy.

The ERDA brings together in a single agency the major Federal energy research and development programs, and bears the responsibility for leading the national effort to develop the needed technology to assure that the United States will have ample and secure supplies of energy. It consolidates major R & D functions previously handled by the United States Atomic Energy Commission, Department of the Interior, National Science Foundation and Environmental Protection Agency. ERDA also will continue the basic research, materials production and weapons programs of the AEC.

The NRC carries out the licensing and regulatory functions formerly assigned to the AEC, and as a primary activity devotes its attention to assuring the safety as well as the reliability of commercial nuclear electrical power. It has been anticipated that the creation of NRC should end the concern that some have expressed about the past when one agency, the AEC, was assigned the responsibility for both the technological development and the regulation of civilian nuclear power.

Licensing of Major Nuclear Facilities – Early Site Review

In May, the Nuclear Regulatory Commission forwarded to the Congress a legislative proposal to improve the licensing process for major nuclear facilities, which was introduced as S. 1717 and H.R. 7002. In hearings conducted in June by the Joint Committee on Atomic Energy, the Commission strongly supported the proposed licensing reform legislation as a measure that could lead to reduction of the time now required to bring a nuclear power plant on line from eight or more years to about six years.

The basic concepts of early site approvals and standard plant designs are at the heart of the proposed legislation. The Commission noted it would provide a more efficient framework for siting and licensing without impairing the quality or thoroughness of the NRC's safety, anti-trust or environmental reviews, or depriving the Commission or the public of the benefits of full public participation in the process. It would make a major contribution to attainment of more efficient, effective regulation which is essential if nuclear power is to be a viable option in meeting the country's need for electric energy.

Main features of the proposed legislation are:

(1) Provision for approvals of sites for nuclear plants independent of construction permit applications. Site permit applications could be filed by interested States as well as by utilities proposing to construct plants. An inventory of approved sites could be developed. There would be a complete environmental review and opportunity for formal hearing before issuance of any site permit.

(2) Encouragement of standardization of nuclear plants by providing for combined construction permits and operating licenses, by encouraging early public participation in the resolution of plant design questions, and by avoiding duplicate hearings.

(3) Enhancement of public participation by providing for hearings on site suitability and design questions at early points in time when they can be most effective, and by providing for certain assistance to hearing participants.

Extension and Modification of the Price-Anderson Act

The Price-Anderson Act was enacted in 1957, and extended and amended in 1965, and 1966. The Act was designed to protect the public by providing for the payment of claims in the unlikely event of a catastrophic nuclear incident. Among other things, the Act provides funds for public liability in the event of a nuclear incident up to a total amount of $560 million. This amount is provided for by requiring nuclear power plant licensees to maintain financial protection through insurance or other means in the full amount available from private insurance (currently $125 million) and by providing for government indemnity for the remainder of the $560 million. Other features included in the Act by the amendments of 1966 are no-fault liability and provisions for accelerated payment of claims immediately upon occurrence of a nuclear incident.

The question of whether to extend the Price-Anderson Act received extensive consideration during the 93rd Congress. After comprehensive hearings, the Joint Committee on Atomic Energy reported out a bill, H.R. 15323, which was passed by the Congress with amendments and sent to the President on October 1, 1974. The President vetoed the measure on October 12, 1974, citing his approval of the substantive sections of the bill and basing his veto on "the clear constitutional infirmity of a provision in the bill which allowed the Congress to prevent it from becoming effective by passing a concurrent resolution within a specified time."

On June 9, 1975, the Nuclear Regulatory Commission submitted to the Joint Committee the report on the subject of sabotage and the theft of nuclear materials which had been requested by the Conference Committee on H.R. 15323.

On July 10, 1975, the Federal Energy Administration forwarded to the Congress proposed legislation which was introduced as H.R. 8631 and S. 2568. These bills were identical to the bill which was passed by the 93rd Congress with two exceptions: first, the provision which caused the President to veto the bill was omitted; and second, the measure called for a 10-year rather than a 5-year extension of the Act.

The major change to existing law which would be made by the bills is a provision for replacing the Government indemnity with a retrospective premium insurance system over a period of years as more power reactors become licensed. This system would also allow an increase in the limit on liability above $560 million after Government indemnity has been phased out. This is expected to occur no later than 1985. Price-Anderson coverage would also be extended to offshore nuclear power plants and to shipments of nuclear material between NRC licensees via routes wholly or partially outside U.S. territorial limits.

The bills were referred to the Joint Committee and hearings were held on September 23 and 24, 1975, to consider that measure and the question of whether the Price-Anderson system should be extended to cover sabotage and the theft of nuclear materials. At those hearings, the Committee heard testimony from the nuclear power and insurance industries, the electric utilities, the Executive Branch, and a number of other organizations interested in this subject.

On December 16, 1975, the Senate considered and adopted three amendments to S. 2568. By a vote of 76–18, the Senate then voted to pass H.R. 8631 with the Senate amendments. On December 17, 1975, the House agreed to the Senate amendments to H.R. 8631. The President signed the bill on December 31, 1975 (Public Law 94–197).

In its report on the bill to amend and extend the Price-Anderson Act, the Joint Committee requested that the Nuclear Regulatory Commission review the need for extending the Price-Anderson system to include plutonium processing facilities. The Nuclear Regulatory Commission advised the Committee on December 3, 1975, that once H.R. 8631 has been signed into law, the NRC will publish a "Notice of Intended Rule Making" as the first step in implementing the legislation. This notice will solicit the views of the public and interested groups on the question of extending Price-Anderson coverage to plutonium processing facilities and to the transportation of nuclear material to and from those facilities. Based upon those views, NRC will then decide whether Price-Anderson coverage should be extended.

Joint Committee on Atomic Energy (JCAE)

During the 94th Congress, First Session, the JCAE held public hearings directly related to radiation protection problem areas.

Liquid Metal Fast Breeder Reactor Program

On March 19, 1975, Senator John O. Pastore, Chairman of the Joint Committee on Atomic Energy, established a Subcommittee under the chairmanship of Representative Mike McCormack to review the Liquid Metal Fast Breeder Reactor (LMFBR) Program and related activities of the Energy Research and Development Administration. The purpose of this review was to examine the various concerns that have been expressed and questions that have been raised within the Congress and outside by members of the public with respect to several fundamental issues such as the need and timing of the breeder program, the cost and potential benefits to be realized from it, and the attendant risks associated with the ultimate widespread commercial use of this type of energy production and conversion technology.

During the spring and summer, the Subcommittee held a series of public briefings and hearings on the history of the nuclear power program, the nuclear fuel cycle, reactor types and characteristics, the enrichment process, present status of the civilian nuclear power plant program and the role of utilities in the Clinch River Breeder Reactor Project.

Throughout June and July, during a series of seven public hearings, the Subcommittee received oral testimony from representatives of government agencies, private industry, public groups and individuals presenting information on both sides of the issue relevant to the need for the breeder program. These included energy trends, alternate energy sources, safety and environmental considerations, safeguards, role of converter and breeder reactors, and cost-benefit analyses.

The Subcommittee has prepared a report stating its views, conclusions and recommendations with regard to the need and timing of the breeder. It is planned that this report will be published early in 1976.

Nuclear Power Reactor Safety

The Joint Committee continued to devote major attention to the subject of nuclear power reactor safety over this past year. This was done in recognition of the fact that nuclear activities must be carried out in a manner which fully protects the health and safety of the public and which minimizes the impact of these activities on the environment. The health and safety record in the nuclear programs has been excellent, and there have been no commercial radiation accidents in this country which have in any meaningful way jeopardized the public or the environment.

As part of its continuing attention to matters of safety significance, the Joint Committee held a hearing February 5, 1975, on the Nuclear Regulatory Commission (NRC) action of January 30, 1975, requiring the operators of 23 boiling water reactors to perform prompt safety inspections of certain piping in their plants. The purposes of this hearing were to determine the full extent of the situation requiring reactor shutdowns, its impact on the nuclear power program, and to bring this matter fully and openly to the attention of the public. The precautionary shutdown action was taken by NRC after the discovery of pipe defects in several operating boiling water reactors. Testimony was received at the hearing from NRC and the Union of Concerned Scientists. The hearing clearly brought out the fact that the piping problems presented no hazard to the public, and that there had been no releases of radioactivity associated with the defects in the affected operating plants. During the inspections ordered by NRC, no additional cracks were found in the pipes of 22 of the plants; one plant reported that it had found one additional small crack in its piping. All pipes in which cracks were identified have been replaced.

The Joint Committee also held a hearing September 16, 1975, on the circumstances and implications, particularly from the standpoint of nuclear safety, of a fire which occurred on March 22, 1975, at the Tennessee Valley Authority's Browns Ferry Nuclear Plant. The purpose of this hearing, as in the previous case, was to examine the causes and impact of the event in question, and to bring this safety-related matter to the attention of the public. Testimony was received from the Nuclear Regulatory Commission, The Tennessee Valley Authority and the State of Alabama.

The record of this hearing showed, contrary to numerous reports in the media, that the fire did not constitute a "near disaster" and that sufficient backup systems were available at all times to provide necessary cooling of the nuclear reactor cores. There was no unusual release of radioactivity to the environment, and no hazard was presented to the public. Although the hearings demonstrated that improvements are needed in design practices and operating procedures to minimize the possibility and consequences of such fires in the future, the incident showed that nuclear power plants indeed have a large margin of safety built into them.

On October 30, 1975, the Nuclear Regulatory Commission transmitted to the Joint Committee the final report of the Reactor Safety Study, which is generally referred to as the Rasmussen Report. The study, which was conducted over a three-year period, undoubtedly represents the most comprehensive risk assessment of nuclear plants ever made. The Joint Committee has strongly encouraged and supported this effort to quantify the risks associated with nuclear power, to put these risks into overall perspective, and to communicate these matters to the public in terms the layman can understand.

Radioactive Waste Management

On November 19, 1975, the Joint Committee held a public hearing on the policies, plans and programs of the Executive Branch to provide for the safe storage and disposal of radioactive wastes produced in the commercial nuclear fuel cycle. This hearing was a part of the Committee's continuing efforts to stimulate the development of a comprehensive waste disposal program. Among these efforts was the Committee's directive in its report on the bill authorizing ERDA appropriations for fiscal year 1976 that ERDA prepare a comprehensive and detailed analysis of the options for storage and disposal of commercially generated radioactive wastes.

During the hearing, the Committee received testimony from ERDA on its research, development and demonstration activities on waste processing, storage and disposal. Testimony was also presented by the Nuclear Regulatory Commission and the Environmental Protection Agency on the standards and regulations being developed to assure the safe handling and disposal of radioactive wastes. The hearing served to show that there are no basic technical problems standing in the way of demonstrating an acceptable program for the disposal of radioactive wastes. The Committee will continue to devote major attention to this subject. The record of this hearing was published in 1975.

STATE REGULATIONS

"Suggested State Regulations for Control of Radiation" have been prepared and distributed to State radiation control agencies for their use. The current regulations revise, update and expand the 1970 edition, and were prepared by the FDA's Bureau of Radiological Health, the former USAEC and the Conference of Radiation Control Program Directors. The revised suggested regulations, often referred to as "model State regulations," reflect changes in National Council on Radiation Protection and Measurement guidelines, new amendments to AEC regulations, and electronic product radiation safety performance standards issued by the Bureau. They are intended primarily as guidance for State radiological health programs developing or amending their radiation control regulations (See Chapter 4).

In the report "Report of State and Local Radiological Health Programs – Fiscal year, 1974," which was published by the Bureau of Radiological Health, is included the following legislative information:

> Since 1951, a total of 47 States and the Commonwealth of Puerto Rico have enacted specific laws for the regulation of ionizing radiation. Some of these laws are restricted to certain occupations or are amendments to existing statutes. In Iowa, Rhode Island, West Virginia, and the District of Columbia, the responsibility for some aspects of radiation protection is assumed under general public health laws. The technical details of regulatory control are generally not included in these enabling acts; rather this authority is delegated to State agencies.
>
> The Nuclear Regulatory Commission has entered into agreement with 25 States for regulating specific material previously under Atomic Energy Commission control. The State of New Mexico signed an agreement with the Atomic Energy Commission in May 1974.
>
> As of June 30, 1974, 16 States had approved legislation for the regulation of nonionizing electromagnetic radiation, and four States have approved specific legislation for the registration of laser devices. Nine States and the Commonwealth of Puerto Rico have approved specific laws which establish minimum standards for the education, training, and experience of certain user groups that apply ionizing radiation to human beings for diagnostic or therapeutic purposes.

Section 274 of the Atomic Energy Act authorizes the Nuclear Regulatory Commission to enter into agreements with States whereby they assume regulatory authority over radioisotopes, source materials, and special nuclear materials in quantities not sufficient to form a critical mass (a mass capable of supporting a self-sustaining chain reaction).

At the end of 1975, there were 25 Agreement States exercising regulatory jurisdiction over a total of approximately 10,500 nuclear material licenses, in addition to about 8,500 such licenses administered directly by NRC. The Agreement States were: Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Oregon, South Carolina, Tennessee, Texas, and Washington.

During the year, active negotiations were underway with Illinois, Michigan and New Jersey preparatory to entering into regulatory agreements.

On January 23, 1976, the U.S. Nuclear Regulatory Commission published in its "Information Report on State Legislation" a summary of laws affecting nuclear power plants which were enacted by the States during the 1975 legislative session. Appendix A shows pertinent laws excerpted from this report and a compilation of initiatives affecting nuclear energy.

INITIATIVES AFFECTING NUCLEAR ENERGY

Non-Government Standards/Guides

NCRP

During 1975 the National Council on Radiation Protection and Measurements (NCRP) published four reports:

NCRP Report No. 43, "Review of the Current State of Radiation Protection Philosophy." The report is a position statement of the NCRP on issues that emerged as a result of the publication of reports by the United Nations Scientific Committee on the Effects of Atomic Radiation and the National Academy of Sciences – National Research Council's Advisory Committee on the Biological Effects of Ionizing Radiation. The NCRP indicated that although those two reports essentially reached the same numerical results for radiation levels at which observations are available, there have been differences in philosophy and divergent conclusions regarding the estimation of the risk associated with low-level, low-dose rate radiation, for which little or no data are available. Further, the Council believes that perhaps more importantly, widely varying interpretations of the significance and meaning of those reports and conclusions have been formulated.

The NCRP undertook an extensive analysis of the published materials and the underlying background. On the basis of this review and recent developments relating to radiation standards for the public, particularly in regard to extrapolated estimates of cancer risk at low doses and low-dose rates, the Council took the position that no change is required, at the time of publication of Report No. 43, in the conclusions and dose limits set out in NCRP Report No. 39 which was issued in 1971.

NCRP Report No. 44, "Krypton-85 in the Atmosphere-Accumulation, Biological Significance, and Control Technology." Krypton-85 is released to the atmosphere through nuclear weapons tests and the generation of nuclear electrical power. With the partial cessation of atmospheric testing of nuclear weapons 85Kr in the atmosphere results primarily from the reprocessing of nuclear fuel, very little being released from the actual operation of the nuclear power plants themselves. The report estimates the future global concentrations of 85Kr in the atmosphere resulting from projected future levels of nuclear power use, the absorbed doses to man resulting from these concentrations, and possible techniques which may prove practicable for the future control of krypton-85.

NCRP Report No. 45, "Natural Background Radiation in the United States" is concerned with the assessment of the radiation dose to the population from natural background exposures. The report presents the measurements and calculations of dose equivalent rates for the tissues and organs of interest to all natural sources, such as cosmic radiation, internal and external radionuclides.

NCRP Report No. 46, "Alpha-Emitting Particles in Lungs." Release of particulate plutonium and transplutonium alpha-emitting elements from nuclear facilities poses questions concerning body distribution of dose and the resultant biological effects. The NCRP developed a statement on the question of whether the current practice of averaging over the lungs the absorbed dose from particulate alpha-emitting radionuclides is a defensible procedure in the practice of radiation protection, and whether exposure limits derived on this basis are more or less conservative than those that might result from a precise consideration of the spatial distribution of the dose.

The main conclusions from the report are that (1) The substantial body of experimental data available at the present time indicates that particulate plutonium in the lung is no greater hazard than the same amount of plutonium more uniformly distributed throughout the lung; and (2) The current NCRP practice of averaging over the lung the absorbed dose from particulate alpha-emitting radionuclides is a defensible procedure when employed in conjunction with appropriate dose limits.

HEALTH PHYSICS SOCIETY

During 1975 the Health Physics Society in conjunction with its Standards Committee, assumed the responsibility of the Secretariat for the American National Standards Insitute of its Main Committee N-13 "Radiation Protection." The Secretariat formerly had been with the Atomic Industrial Forum.

At the present time under this program there are 15 scientific groups actively involved in the development of standards. The following are examples of standards already developed or that are in the process of development.

Criteria for Testing Personnel Dosimetry Performance

At the April 1975 meeting of the National Conference on Radiation Control Program Dosimetry Task Force II (Hyannis, Massachusetts), the Health Physics Society was requested to establish a committee to develop a standard on "Criteria for Testing Personnel Dosimetry Performance." Basic data accrued through a Bureau of Radiological Health supported program will provide the basis for the technical specifications in the standard.

This important area of work owes its beginning to the interest of the Conference of State Radiation Control Program Directors where at their 1973 annual meeting, they cited the need to establish a national quality assurance program for personnel dosimetry. They recommended, as noted in one of their task group reports that, "a Federal agency be designated to direct a continuing performance testing program for suppliers of personnel monitoring dosimeters." A decision was made to have the National Bureau of Standards act as an impartial agency to provide technical direction to the program. The Bureau of Radiological Health in conjunction with the Nuclear Regulatory Commission, the Environmental Protection Agency, and the Energy Research and Development Administration supported the resolution.

The HPSSC Committee is currently developing a first draft which will then be processed through ANSI, Main Committee N-13.

Criteria For Film Badge Performance

This standard provides film badge performance criteria for several categories of radiation following exposure under specified conditions. The standard considers the performance of film dosimetry under the most reproducible conditions. As far as possible, uncertainties introduced by scatter radiation, unspecified radiation sources, and nonuniform irradiations are eliminated from the procedures.

This standard is currently published and may be obtained from the American National Standards Institute.

In-Plant Plutonium Monitoring For Personnel Protection

This standard and its appendix define performance parameters for radiation protection instrumentation essential to in-plant plutonium monitoring. Performance criteria are limited to instruments capable of measuring:

(1) photon radiation within the energy range 0.010 to 1.25 MeV,

(2) neutron radiations within the energy range from thermal to 10 MeV, and

(3) alpha radiation within the emitted energy range of 4.5 to 7.5 MeV.

The standard does not define specifications for personnel dosimetry, effluent monitoring systems or instruments needed in bioassay programs. A final letter ballot action is nearing completion.

Standards for the Unrestricted Release of Radioactivity Contaminated Equipment and Facilities

The standard provides criteria for the control of materials, equipment and facilities contaminated with radioactivit, proposed to be released for uncontrolled use. Permissible contamination limits are specified including methods for assessing the levels of contamination. The following areas will be a matter of separate consideration and beyond the scope of this standard:

1. control of radioactive contamination that is dispersed through material,
2. materials made radioactive by neutron irradiation,
3. contaminated soils, and
4. contaminated clothing and evaluation of contamination on persons.

The standard has just completed a successful letter ballot action and will be processed through the ANSI Board of Standards Review.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

Approximately 610 nuclear standards are in various stages of development or are in the publication process by the ANSI. Approximately 20% of this total is directed primarily toward radiation protection standards. The ANSI Main Committee, N-13, is the principal committee involved in the development of general radiation protection standards. However, other committees such as N-43 also develop radiation standards but specifically within the scope of their charters.

The following are three examples of ANSI standards activities in cooperation with the Health Physics Society:

"Performance, Testing and Procedural Specifications for Thermoluminescent Dosimetry (Environmental Applications)." The standard has been published.

"Control of Radioactive Surface Contamination on Materials, Equipment and Facilities to be Released for Uncontrolled Use." The standard is in the process of publication.

"Personnel Monitoring with Thermoluminescent Dosimeters." The standard is in final draft.

NRC JUDICIAL REVIEW (1)

Federal court actions involving the Nuclear Regulatory Commission during 1975 include nine cases decided, four cases argued and awaiting decision, and two cases pending.

Cases Decided During 1975

Carolina Environmental Study Group v. AEC, et al., 510 F.2d 796 (D.C. Cir. 1975). On January 21, 1975, the Court of Appeals for the District of Columbia Circuit affirmed a final order of the AEC (now NRC) granting Duke Power Co. a construction license to build two nuclear reactors. Petitioners had contended that the Commission failed to comply with the National Environmental Policy Act because it inadequately considered Class 9 accidents and alternative sources of power in the impact of due process becasue of the AEC's dual role in promotion and regulation of nuclear power. The Court approved the Commission's treatment of Class 9 accidents as hypothetical occurrences whose probability was extremely remote.

The Conservation Society of Vermont, et al. v. AEC. On April 17, 1975, a three-judge district court dismissed a complaint which challenged the constitutionality of the Atomic Energy Act on the ground that it vested both developmental and regulatory functions in the AEC. The action was dismissed because the Energy Reorganization Act of 1974 had rendered the issues moot.

Ralph Nader, et al. v. NRC, et al. On May 30, 1975, the Court of Appeals for the District of Columbia Circuit affirmed the Commission's denial of a petition seeking a shutdown or derating of 20 nuclear power plants previously licensed for operation. The Court agreed with the Commission that a determination of compliance with the Acceptance Criteria is equivalent to a determination of compliance with Criterion 35. It pointed out that the former were detailed specifications implementing the more general Criterion 35.

Porter County Chapter of the Izaak Walton League of America. Inc., et al. v. AEC, et al. On April 21, 1975, the United States Court of Appeals for the Seventh Circuit set aside the NRC construction permit for the nuclear power reactor proposed for the Bailly site on Lake Mighigan in Northern Indiana. The Court denied the Government's petition for rehearing or rehearing *in banc.* In so ordering, the original three-judge panel observed "We find nothing in the Atomic Energy Reorganization Act of 1974 which would prevent NIPSCO from applying for another license or would prevent NRC from considering such new application."

On June 16, 1975, NRC requested that the Solicitor General authorize the filing of a petition for a writ of certiorari in the Supreme Court. The Solicitor General filed a memorandum supporting the suggestion of Northern Indiana Public Service co. that the case be summarily reversed. On November 11, 1975, the Supreme Court reversed the judgment of the Seventh Circuit and remanded the case for consideration of questions which that court had not decided. The Supreme Court held that the Seventh Circuit had erroneously rejected the NRC's interpretation of its own power plant siting regulations.

The State of New York v. NRC, et al. (S.D.N.Y., 75 Civ. 2121). The State of New York claimed that several Federal agencies, including NRC, had violated the National Environmental Policy Act by transporting and allowing the transport of special nuclear material, particularly plutonium, by air without having first prepared an Environmental Impact Statement. The agencies agreed to prepare an impact statement and re-examine pertinent regulations. The State of New York sought a preliminary injunction suspending air transport of the material pending completion of the impact statement and associated rulemaking procedures. The petition was denied, the Court noting that air shipment was inherently a better protection from theft than surface transport and that, with the safety record of such shipments in the past, the State's contention that irremediable harm could ensue without immediate suspension was not convincing.

On August 9, 1975, Congress enacted Public Law 94-79, prohibiting the licensing by NRC of any air shipments of nuclear material except that contained in certain medical devices designed for individual human use. The restriction will remain in force until NRC has certified to the Joint Committee on Atomic Energy that a safe container has been developed.

Environmental Coalition on Nuclear Power, et al. v. NRC, et al. (3rd Cir., 75-1421). Petitioners sought review of an Order issuing construction permits for Limerick Generating Station, Units 1 and 2, of the Philadelphia Electric Co. They contended that the Commission's review concerning cooling water for the facility was not in accordance with the National Environmental Policy Act. In its brief, the Commission contended that its environmental review was complete and that Limerick was economically and environmentally sound when operated on the basis of natural river flow. As the Commission further stated, alternative methods of operation which would increase the plant's economic efficiency will not be authorized until and unless they too can be shown to comply with NEPA. On November 12, 1975, two days after it heard oral argument, the court issued an order denying the petition of review.

York Committee for a Safe Environment, et al. v. NRC (D.C.Cir., 74-1923). On December 9, 1975, the United States Court of Appeals for the District of Columbia, rejecting numerous other objections raised by the petitioners to the grant of an operating license for the Peach Bottom Atomic Power Station, Unit 2, remanded the case to the Commission for an individualized analysis of the costs and benefits of reducing routine radioiodine releases in accordance with the Commission's "as low as reasonably achievable" regulations. The Court rejected the petitioners' contentions that the licensee's emergency plans did not comply with the Commission's regulations and that the Commission had violated the National Environmental Policy Act by giving inadequate consideration to the transportation of spent fuel and to the cumulative effects of the operation of existing and planned reactors in the vicinity of Peach Bottom.

Citizens for Safe Power, Inc., et al. v. NRC, et al. (D.D. Cir., 74-1186). Contending that the Atomic Energy Act requires, beyond compliance with safety regulations implementing the Act, a consideration of "residual" risks, petitioners sought review of an order granting an operating license for the Maine Yankee facility. The Commission responded that the Act does not require such additional consideration because the regulations themselves embrace a consideration of such risks. Moreover, such residual risks were expressly considered in review under the National Environmental Policy Act. On December 24, 1975, the Court issued its opinion holding that the Commission's action complied with the Atomic Energy Act and was an adequate assessment, in the context of NEPA review, of the residual risk.

Hudson River Fisherman's Assoc., Inc., et al. v. NRC (2d Cir. No. 75-4212). Petitioners challenged the Appeal Board's Order interpreting—and approving as interpreted—a stipulation which they executed jointly with the other parties to NRC's adjudicatory hearing concerning issuance of an operating license for Unit 3 of the Indian Point Nuclear Generating Station. Following the Commission's December 2, 1975 Order approving the stipulation and vacating portions of the Appeal Board's decision, the court dismissed the suit on December 10, 1975.

Cases Argued and Awaiting Decision

North Anna Environmental Coalition v. NRC, et al. (D.C. Cir., 75–1312). Petitioners seek review of a Commission determination allowing Virginia Electric and Power Co. to continue construction of four reactors at the North Anna site. After a hearing, the Commission determined that a geological fault on which the reactors were sited was not a "capable fault" and therefore posed no danger to the public health and safety. The court heard oral argument on November 20, 1975.

Lloyd Harbor Study Group v. NRC, et al. (D.C. Cir., 73–2266). Petitioners seek review of an order granting a construction permit for the Shoreham nuclear facility. At issue in the case is whether nuclear fuel cycle effects attributable to this particular plant—which are identical to those from all other reactors and which were the subject of an ongoing generic rulemaking proceeding—had to be considered in the environmental impact statement. Another issue, identical to the question decided in *Carolina Environmental Study Group*, is whether the National Environmental Policy Act requires a detailed analysis of the consequences of Class 9 accidents. The case has been briefed and argued and awaits action by the Court.

Natural Resources Defense Council, Inc., et al. v. NRC, et al. (D.C. Cir. Nos. 74–1385 and 74–1586). These two cases were consolidated for oral argument. In number 74–1586, the petitioners challenged the Commission's issuance of a rule prescribing the manner of accounting, in individual licensing cases, for the environmental consequences of the uranium fuel cycle activities attributable to the particular plant. In number 74–1385, petitioners challenged the Commission's issuance of the Vermont Yankee operating license. Relying on NEPA, they attack the Commission's treatment of environmental effects of fuel cycle activities attributable to Vermont Yankee Operation.

Aeschliman, et al. v. NRC, et al. (D.C. Cir. 73–1776) and *Saginaw Valley Nuclear Study Group, et al. v. NRC, et al.* (D.C. Cir. 73–1867). Petitioners in these companion cases seek review of Commission orders granting construction permits for Units 1 and 2 of the Midland facility in Michigan. At issue is the Commission's decision to evaluate emergency core cooling systems and impacts of the nuclear fuel cycle by generic rulemaking rather than in separate adjudications. By order of the Court the cases were held in abeyance pending determination of the related fuel cycle issues in the above-mentioned cases brought by the Natural Resources Defense Council.

Other Pending Cases

City of Cleveland, Ohio v. NRC (D.C. Cir. No. 75–2115). The City of Cleveland filed, on Nobember 17, 1975, a petition to review a decision of the Atomic Safety and Licensing Appeal Board in a consolidated proceeding involving the Davis-Besse Nuclear Power Station (Unit 1) and the Perry Nuclear Power Plant (Unites 1 and 2). The Appeal Board held that appointment of a Special Master, with the parties' agreement, to decide certain discovery matters did not violate an NRC prohibition against redelegation of the Licensing Board's authority. The Appeal Board also pointed out that the parties had agreed to be bound by the Special Master's discovery rulings.

Carolina Environmental Study Group v. NRC, et al. (U.S.D.C.W.D.N.C., No. C-C-73–139). This suit challenges the granting of a construction permit to Duke Power Company for the McGuire facility in North Carolina. The issues it had in common with the suit of the same name in the Court of Appeals for the D.C. Circuit have been dismissed. The remaining issue is the constitutionality of the limitation of liability in the Price-Anderson Act. Memoranda on the issue have been filed; argument was heard on December 18, 1975. The Court ordered that a further hearing be held.

Though the NRC is not a party to it, special mention is merited of the Supreme Court's grant of certiorari in the case of *Train v. Colorado Public Interest Research Group*, by which the Court has accepted the Government's petition for review of an appellate court decision. The issue before the Court is whether nuclear waste material, regulated and controlled through licenses issued by the NRC, is a "pollutant" within the meaning of the Federal Water Pollution Control Act, which required the Environmental Protection Agency to establish regulations and controls over pollutants by administering a detailed permit program. The U.S. Court of Appeals for the Tenth Circuit, reversing the district court decision, answered this question in the affirmative. The EPA has appealed this decision to the Supreme Court, which heard oral argument from the parties on December 9, 1975.

REFERENCE

1. U.S. Nuclear Regulatory Commission, "Annual Report 1975," pursuant to the requirements of Section 307 (C) of the Energy Reorganization Act of 1974.

NUCLEAR ENERGY – CHAPTER 3

INTRODUCTION

The nuclear power industry, producing electricity to meet over 8 percent of the U.S. demand, is the most visible and controversial of the sources of radiation covered in this report. There are four specific problems which are facing the nuclear power industry. First is the problem of management and handling of radioactive waste such that they can be concentrated, encapsulated, and stored in a manner that will assure full protection of the public both now and in the future. Because of the important role envisioned for nuclear power, a coordinated Federal program is being developed to resolve this problem. Second, there is the complex problem involving the levels of risk individuals are willing to assume for the benefits of low cost power. Even though considerable effort has been devoted to Reactor Safety both at the Federal and State levels, much work remains to be done to resolve the problem. Third, although planned releases from nuclear power plants are low, the buildup of long-lived radionuclides in the environment is of continuing concern. With respect to this problem, EPA's proposed Uranium Fuel Cycle Standard establishes limits on the annual exposure of any member of the public and contains provisions to limit the releases of long-lived radionuclides to prevent any unwarranted buildup of them in the environment. Fourth, as new technologies are developed which use separable fission material such as plutonium, the problem of safeguards needs to be addressed in the public forum and resolved.

Radioactive emissions from nuclear power plants can be reduced to any desired level by appropriate controls. There is an active debate over what is the "desired" level, in view of the mounting costs of increasing control. As an alternative it is possible to locate and design plants such that the radioactive emissions will provide a minimal impact on the environment by locating the plant away from such sensitive areas as population centers. The preparation and review of Environmental Impact Statements promote application of emission reduction systems to assure protection of the public and the environment.

In 1975, there were significant radiation protection activities which are likely to affect the public and the environment in relation to radiation; their sources and measures for their control. For this year the primary focus has been on nuclear power and its control and to a more limited extent on other parts of the nuclear fuel cycle.

INDUSTRY STATUS (1)

By the end of 1975, there were in the U.S. nuclear power industry:

56 plants with operating licenses, representing 38,655 MWe

69 plants with construction permits, representing 70,773 MWe

90 plants on order, representing 100,200 MWe

21 plants firmly planned, representing 26,160 MWe

236 total commitments, representing 236,729 MWe

Nuclear reactors now produce about 8.3 percent of the electric power used in the U.S. In 1975, the industry saw cancellations and deferrals of new construction for two dozen plants. Figure 3.1, charting annual orders, clearly shows a rising trend in plant orders that weakened in 1974, and plummeted to only five orders in 1975. Due in part to an abrupt halt in the historic growth of electric power usage, and a feeble resumption of demand in 1975, nuclear growth is also plagued by the tight capital market utilities must tap to meet the high initial cost and long construction cycle for a modern nuclear plant. Nevertheless, as presently scheduled, the U.S. capacity for electric power will rise a factor of 5 by 1986, as shown in Figure 3.2.

MEETING STANDARDS FOR NORMAL RELEASES

Planned releases of radioactive wastes from nuclear reactors are to the atmosphere and the water body cooling the plant condensers. Gaseous wastes are filtered, retained to permit some decay of short-lived products, and discharged to the atmosphere. Aqueous wastes are discharged to the natural water body or cooling pond.

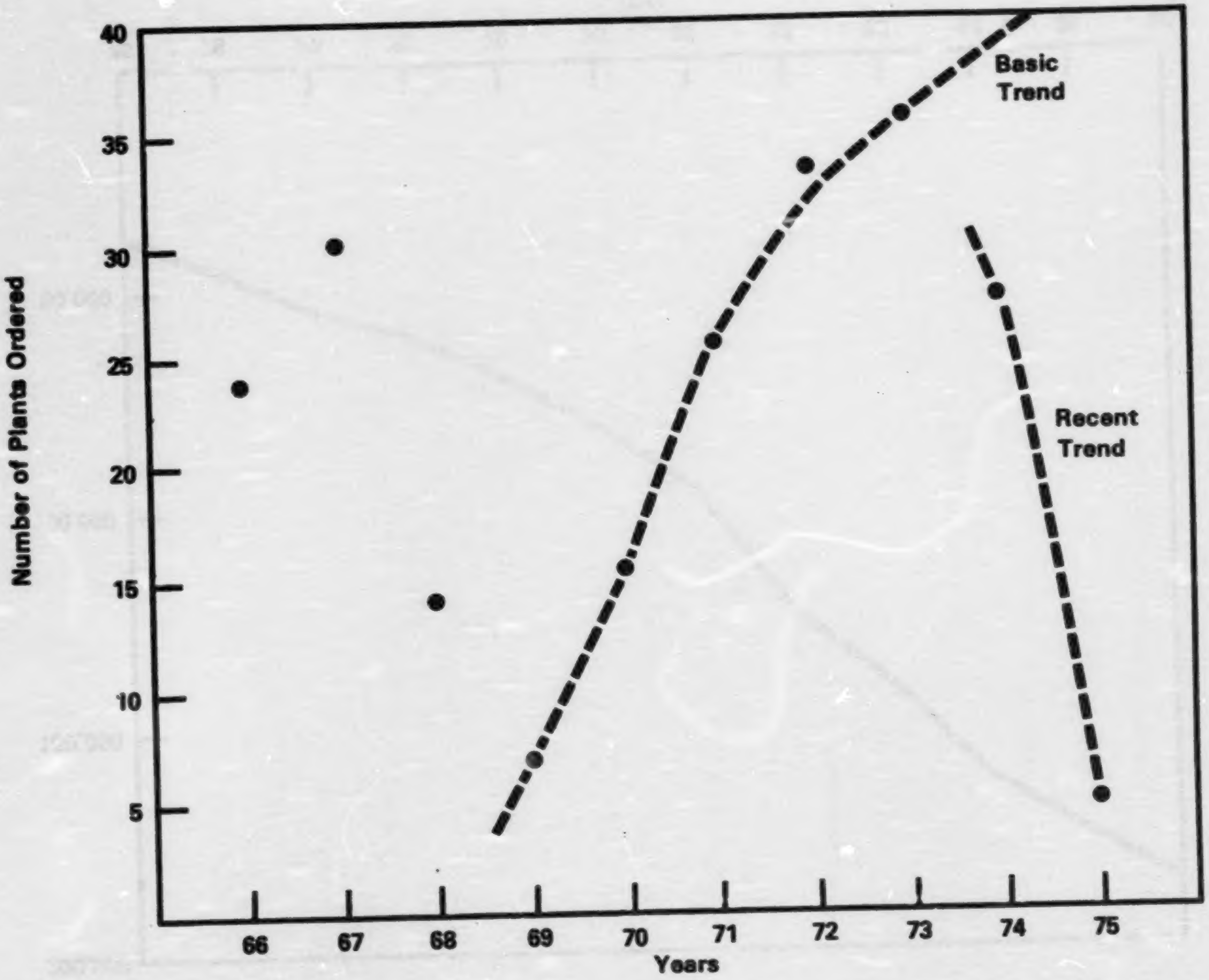
NRC's New Rule on Effluent Control (1)

On April 30, the NRC announced a significant new regulation, effective on June 4, 1975, which provided definitive numerical guidance to NRC licensees on how to comply with the previously enunciated requirement that levels of radioactive material in effluents from light-water-cooled power reactors and resultant doses to the public be kept "as low as reasonably achievable".

The new rule, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," (Appendix I to 10 CFR Part 50) concluded a rulemaking proceeding lasting more than three years which involved an evidentiary public hearing, an environmental statement, more than 4,000 pages of prepared testimony and exhibits.

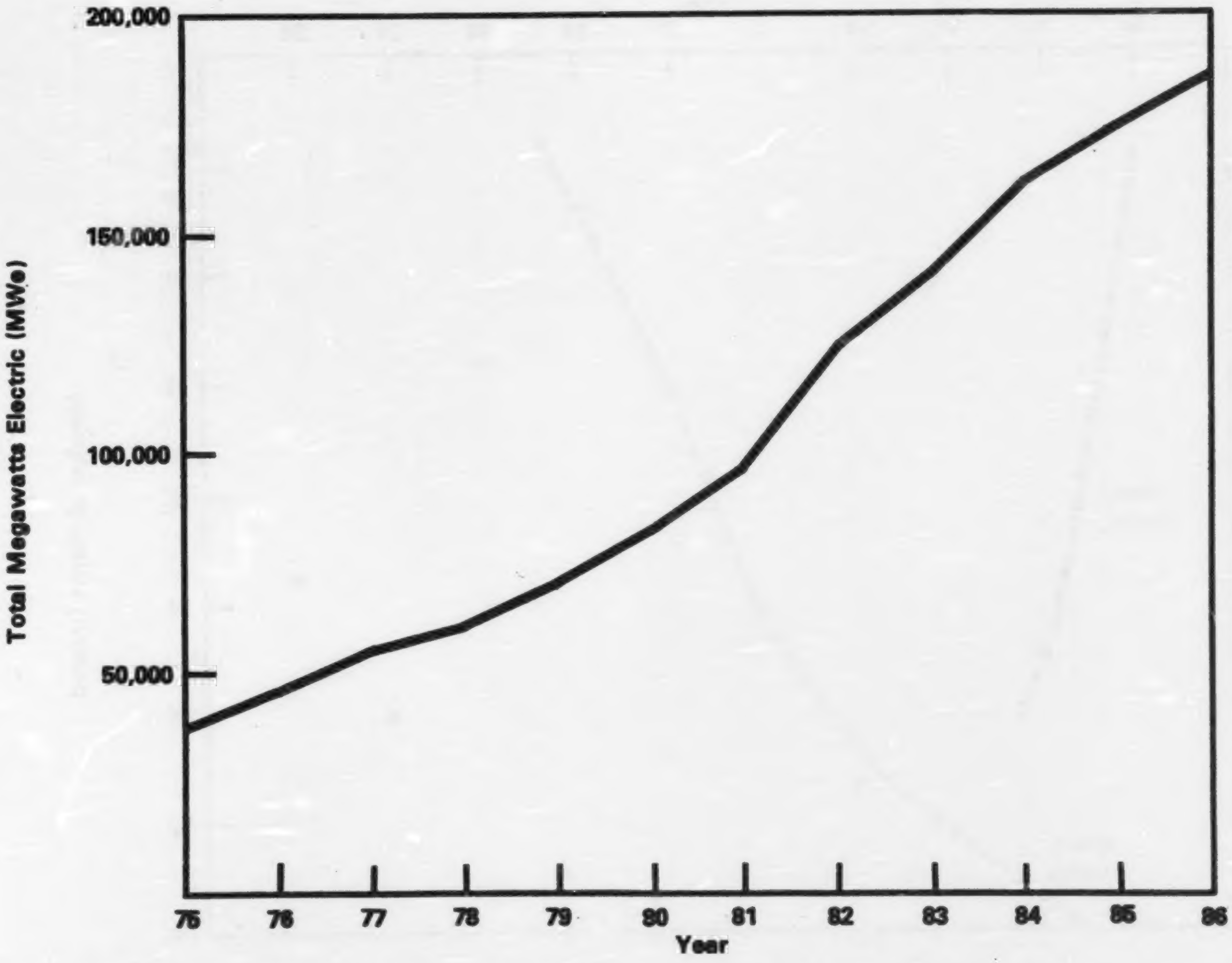
The new regulation involves both design objectives and a cost-benefit analysis requirement to determine the point at which the costs of further reductions of emissions of radioactive material are not justified.

Figure 3.1



U.S. REACTOR ORDERS EACH YEAR. WHILE THE TREND LINE WOULD INDICATE ABOUT THREE DOZEN ORDERS/YEAR MIGHT NOW BE EXPECTED, 1975 ORDERS WERE DOWN TO 5.

Figure 3.2



PRESENTLY SCHEDULED GROWTH OF INSTALLED NUCLEAR CAPACITY IN THE U.S.

The design objectives are to:

(1) Restrict the amount of radioactive material released in liquid effluents from any light-water-cooled power reactor to levels that would keep the annual doses to any individual in an unrestricted area to not more than three millirems for the total body and not more than 10 millirems for any single organ;

(2) Restrict the amount of radioactive material in gaseous effluents from any light-water-cooled power reactor to keep annual doses to any individual in an unrestricted area to not more than five millirems to the total body and not more than 15 millirems to the skin; and

(3) Restrict the amount of radioactive iodine and other radioactive material in gaseous effluents from any light-water-cooled power reactor to keep annual dose to any organ of any individual in an unrestricted area to no more than 15 millirems.

In its decision the NRC adopted a landmark technique—a quantitative approach—for assessing the cost-benefit of achieving further reductions in emissions of radioactive material. This approach seeks, for the first time, to express both the costs and benefits of a reduction in radiation exposure levels in comparable units in order to achieve an objective cost-benefit balance. Contributions to the record in the rulemaking proceeding comparing the costs of further measures to the benefits of any reduction achieved ranged from $10 to $980 for total-body exposure to a standard unit of radiation dose equivalent, the "man-rem." (The man-rem is a measure of collective dose equivalent for large groups of people—for example, 100 people, each receiving 0.01 rem; or 1,000 people each receiving 0.001 rem.)

In September 1975, the Commission amended the regulation to provide an optional method for certain reactors to come in compliance with the guidelines. Under this option, applicants filing for construction permits on or after January 2, 1971, and before June 4, 1976, may comply with the "as low as reasonably achievable" regulation without making the newly required cost-benefit analysis, provided their radioactive waste systems and equipment meet the guides on design objectives that were proposed by the regulatory staff of the AEC in February 1974.

EPA'S Proposed Uranium Fuel Cycle Standard (2)

The EPA published in the *Federal Register* on May 29, 1975, a notice of rulemaking for the Uranium Fuel Cycle designed to provide environmental and public health protection. These standards would limit quantities of long-lived radioactive materials in the general environment attributable to planned releases from operations contributing to the generation of electric power through the uranium fuel cycle. These proposed standards will limit radiation exposure from planned releases outside the boundaries of nuclear power light water reactors and outside of all facilities, including transportation, that are involved in the processing, fissioning, and reprocessing of uranium for these reactors. The standards will cover the process from the time uranium ore leaves the mines through the reprocessing of uranium after burnup in reactors and its eventual recycling back into the fuel supply. This will (a) assure protection of the public against radiation doses resulting from fuel cycle operations, and (b) limit the long-term impact on current and future population of long-lived radioactive materials that accumulate as a result of the production of electrical energy. The guideline for this standard is the "as low as reasonably achievable" concept. Effective consideration of "as low as reasonably achievable" involves judgments of trade-off between public health considerations, cost of effluent control, and overall benefit. The proposed standards for individual doses and for limits on total quantities of long-lived radionuclides are presented in Table 3.1.

Standards in categories of Section A of Table 3.1 are designed to address doses due to short-lived fission produced materials and naturally occurring materials, while those in Section B specifically address long-lived radioactive materials. The standards for environmental burdens of specific long-lived radionuclides are expressed in terms of the quantity of electricity produced, in order to assure the public that the risk associated with any long-term environmental burden is incurred only in return for a beneficial product: electrical power. The standard permits these radionuclides to be released up to the specified level at any time or location and at any rate that will not exceed the individual dose limitations. The standards proposed apply to all operations except mining within the fuel cycle, including milling, conversion, enrichment, fuel fabrication, operation of light-water-cooled reactors, fuel reprocessing, and transportation of radioactive materials in connection with any of these operations. A variance is proposed to permit temporary operation in the presence of unusual operating conditions to assure the orderly delivery of power.

Table 3.1

Proposed May 1975 Standards for Normal Operations of the Uranium Fuel Cycle

A. Individual Dose Limits

1. Whole body	25 millirems/year
2. Thyroid	75 millirems/year
3. Other organs*	25 millirems/year

B. Limits for Long-Lived Radionuclides

1. Krypton-85	50,000 curies/gigawatt-year
2. Iodine-129	5 millicuries/gigawatt-year
3. Transuranics**	0.5 millicuries/gigawatt-year

C. Variances

At the discretion of the regulatory agency (licensor) for temporary and unusual operating circumstances to insure orderly delivery of electrical power.

D. Effective Dates

1. Two years, except
2. 1983 for krypton-85 and iodine-129.

*any human organ except the dermis, epidermis, or cornea.
**limited to alpha-emitters with half-lives greater than one year.

ENVIRONMENTAL IMPACT STATEMENTS

According to the National Environmental Policy Act of 1969, a Federal action which can conceivably affect the environment must be preceded by the issuance of a draft environmental impact statement for comment. Comments received must be reviewed and the action modified where necessary to protect the environment before a final environmental impact statement (EIS) can be issued and the action carried out.

Such an action is the issuance of a permit by NRC to construct or a license to operate a nuclear power plant. During 1975, NRC issued for comment 13 draft EIS's and 16 final EIS's on conventional light-water cooled nuclear power plants. Also, TVA issued one draft and one final EIS on a conventional nuclear power plant. EPA reviewed and commented on each of these draft statements.

The principal issues identified by EPA in all the reviews related to:

risks of severe nuclear accidents,

ultimate disposal of nuclear waste,

impacts of the associated fuel cycle, notably dose commitments, and

impacts of necessary transportation of nuclear materials.

Each of these concerns is broad and not confined to one or several EIS's. As such, it requires resolution on a broad basis. Problems which were specific to projects related to reliance on environmental dilution to reduce doses, rather than in-plant effluent control; thyroid dose problems where a site was in a dairy region, radiation source terms; doses due to the use of sewage waste water contaminated with active iodine; source terms for shipment of low-level solid radwaste; and the disposal of demineralizer resin-filter sludges via settling ponds with subsequent shallow-land burial at municipal sites.

During 1975, NRC also published a draft EIS on a generic site evaluation on off-shore power system floating nuclear power plants. The novelty of this concept suggests that it is worthwhile to discuss in detail.

FLOATING NUCLEAR POWER PLANTS

A number of Government agencies and organizations have statutory responsibility and regulatory authority over activities taking place in the ocean. In recognition of this multi-agency involvement in the licensing of floating nuclear power plants, an Interagency Regulatory Steering Committee was formed to minimize duplicative efforts, clarify policy and provide an efficient regulatory process for industry and the public. Departments and agencies of the Federal Government represented on the Committee are: Coast Guard, Corps of Engineers, Council on Environmental Quality (observer), Department of the Interior, Environmental Protection Agency, Federal Aviation Administration, Federal Energy Administration (observer), Federal Power Commission, National Oceanic and Atmospheric Administration, and the Nuclear Regulatory Commission. The NRC representative serves as chairman of the Committee, which has existed since 1973.

For each of the major phases in the licensing process for a floating nuclear power plant, agencies represented on the Committee have identified the key points at which a required regulatory or coordination function must be undertaken by one or more of them. The principal phases are: construction of the manufacturing facility; manufacture of the floating nuclear power plants; construction of offshore and onshore facilities at the proposed site of the floating nuclear plant to the operating site and its installation in the breakwater; operation of the nuclear power plant.

Offshore Power Systems, Inc. applied in 1973 to the Atomic Energy Commission for a license to manufacture eight floating nuclear power plants. NRC is issuing the Environmental Statement for the application in three parts. The first was issued as a draft in July 1974 and pertained to the environmental aspects of the manufacturing facility at Blount Island, near Jacksonville, Florida. There was little radiological concern with the statement since the only potential source of exposure would be through radiographic inspection procedures. The final EIS (first part) was issued in October 1975.

The second part of the statement, issued in December 1975, pertains to the generic aspects of siting and operation of floating nuclear power plants on the Atlantic and Gulf Coasts. Part three will supplement the generic evaluation by considering the liquid pathways in detail for radiological releases under both normal and potential accident conditions. Part three is expected to be issued in 1976.

The first application to NRC for a license to site and operate floating nuclear power plants was presented by Public Service Electric and Gas Company of New Jersey. The station, Atlantic Generating Station (AGS), is proposed for a site 2.8 miles off the southeastern coast of New Jersey. Current plans are for operation of unit 1 in 1985 and unit 2 in 1987. An environmental statement for AGS was issued April 1976.

HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR)

NRC published its final EIS for the construction of the Fulton Generating Station, Units 1 and 2 in April 1975. The principal comments raised by EPA on the draft statement emphasized the importance of (1) obtaining HTGR operating data at Fort St. Vrain for use in assessing impacts of the large HTGR, (2) developing "as low as reasonably achievable" guidance for HTGR effluent discharges, and (3) developing additional information to more accurately define HTGR risks and consequences from reactor operation and from operation of the HTGR fuel cycle. The final statement was responsive to the EPA comments; however, the details on plans and schedules for obtaining additional operating data and for conducting a risk assessment of the HTGR were not provided.

Fulton Station, and all other previously proposed commercial-sized HTGR (800–1100 MWe class) have been cancelled by the utilities involved. The future development of the HTGR will largely depend on successful operation at Fort St. Vrain, the medium-sized prototype plant, and economics of the HTGR versus the available alternatives.

LIGHT WATER BREEDER REACTOR (LWBR)

A draft EIS for the light water breeder reactor (ERDA-1541) was issued for comment on August 8, 1975. The statement covered the LWBR technology development program and, in particular, the demonstration program at the Shippingport reactor, at which an LWBR core will be installed and operated for three years. The statement addressed both the impacts of a hypothesized commercial LWBR industry and those of the Shippingport plant. The general approach taken was to evaluate the incremental impacts of the LWBR over those which might occur if the nation continued with only its light-water reactors (LWR) currently being utilized.

This program will demonstrate the feasibility of converting existing LWR's, which use low-enriched uranium dioxide as fuel, to use of a thorium oxide-uranium oxide fuel. In the LWBR, the thorium-232 is converted to uranium-233 which can then be used in a conventional LWR. Eventually, A LWBR will produce sufficient U-233 to supply its own reload fuel.

In its comments, EPA found no significant technical issues relative to Shippingport but did conclude that there were sufficient uncertainties with the technology, economics and natural resource utilization that a re-evaluation of the viability of commercial LWBR application would be prudent after the technology is further developed.

NRC'S ENVIRONMENTAL MONITORING (1)

In 1975, the NRC issued a revision to its Regulatory Guide on environmental radiation surveillance. The revised guide "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants" (Regulatory Guide 4.1, Rev. 1), provides the latest guidance on acceptable programs for monitoring radioactivity around nuclear power plants. Such programs are essential for providing additional sssurance that the public health and safety and the environment are adequately protected; they also provide NRC with data by which to determine if the plants are operating within the conditions of their licenses.

Each nuclear facility licensee is required to monitor major and potentially significant paths for release of gaseous and liquid radioactive effluents during normal operation. NRC inspectors check the licensee's radiological monitoring and waste systems to assure they are built as designed and operated to keep releases within regulatory limits. If a regulatory limit is exceeded, the licensee must so inform the NRC and take appropriate action.

Each power plant licensee also is required to monitor major pathways in the environment. During NRC inspections, random samples of monitoring records, procedures, and reports are examined and confirmatory measurements are made to assess the accuracy and consistency of licensee measurements of radioactivity in effluent and environmental samples. The confirmatory measurements are then further compared with NRC reference data developed in laboratory measurements.

Interagency Program

NRC enlisted the cooperation of the National Bureau of Standards, the Energy Research and Development Administration, the Environmental Protection Agency, and State health and environmental agencies in 1975 to provide corroborative evidence of the environmental and effluent radioactivity measurements submitted by licensees. An example of such cooperation is a system which permits continuous tracking of the accuracy of radioactivity measurements, established by agreement between the National Bureau of Standards and the Health Services Laboratory (HSL) of the ERDA Idaho National Engineering Laboratory. HSL functions as the NRC reference laboratory in such matters, and NRC inspectors regularly compare licensee effluent measurements with those made by HSL on identical effluent samples.

State agencies also assist in long-term, repetitive sampling to evaluate licensees' overall environmental programs. At the end of FY 1975, the 18 States participating in this program were

Alabama, Arkansas, California, Colorado, Connecticut, Florida, Illinois, Maine, Maryland, Michigan, Minnesota, Nebraska, New Jersey, New York, South Carolina, Vermont, Virginia and Wisconsin. Under written contract, NRC provides these States with funds, technical support and training to assist in improving their analytical capabilities.

Another tool for the evaluation of a licensee's analytical capability is EPA cooperation with NRC under a 1975 agreement in the use of its Environmental Radioactivity Laboratory Intercomparison Studies Program at the Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

RADIATION STUDIES AT NUCLEAR FACILITIES

The Office of Radiation Programs conducts field studies on a case by case basis at operating nuclear facilities as a part of its dose assessment program to (a) develop measurement techniques, (b) validate dose computational models, (c) characterize effluents, and (d) determine the ability of technology for control of nuclear wastes to meet design technical specifications.

Haddam Neck Plant

At the Haddam Neck Plant at Haddam Neck, Connecticut, a joint EPA, NRC, and State field study was conducted to obtain data for use in validating a dose model for estimating the external, whole body, cloud gamma dose to exposed populations. The study was intended to provide information on the (a) identity and amount of radionuclides in effluents, (b) influence of station operation on radionuclide discharges, (c) degree of dispersion or concentration of radionuclides in the environment, (d) relative importance of specific radionuclides and vectors in exposing population groups, (e) magnitude of radiation exposure in the environment, (f) applicability of various monitoring and measuring techniques, and (g) the ability of technology for control of nuclear wastes to meet technical design specifications. The report for this study has been published as "Radiological Surveillance Study at the Haddam Neck Nuclear Power Station"(3).

Oyster Creek

The Oyster Creek Nuclear Power Plant at Toms River, New Jersey, was studied by a joint EPA/NRC field study team. The data were gathered for validation of a dose model that estimates the external, whole body, cloud gamma dose to exposed populations. The study objectives were to (a) gain information on individual radionuclides in the effluent as a basis for developing recommended radiological surveillance programs, (b) evaluate programs associated with measuring discharged radionuclides and interpreting results in terms of radiation exposure, (c) observe the movement of critical radionuclides from the plant through the environment under routing conditions of station operation, and (d) determine the ability of the technology for control of nuclear wastes to meet technical design specifications. Report draft prepared to be published in 1976.

Quad Cities Nuclear Power Station

A joint EPA/NRC study was conducted in the vicinity of the Quad Cities Nuclear Power Station, Cordova, Illinois, during June through October 1974. The purpose of the study was to continue a previous study of the iodine-131 air to milk pathway at a BWR nuclear power station begun in 1973. Measurements included (a) release rates of iodine-131 by chemical species at the main chimney and vent, (b) air concentrations of iodine-131 by species at four locations, (c) iodine-131 concentrations in grass at five locations, and (e) iodine-131 concentrations in milk at two locations. Measurement sensitivities were critical to this study and as such there were a limited number of samples with activities below the detection limit. A report of this study is in preparation for publication in 1976.

Cooper Nuclear Station

A joint EPA/ERDA/NRC field study to evaluate ^{16}N skyshine dose was conducted at the Cooper Nuclear Station in Brownville, Nebraska. The sources of the nitrogen-16 dose at the reactor site is from moisture separators and turbines, which are both typically located on the same floor and shielded along a line of sight from ground-level location. The purpose of this study was to obtain nitrogen-16 dose data at locations outside of the building boundaries. The doses at such locations are from skyshine (large angle air scatter) rather than directly from the nitrogen-16 source itself as had been the case in previous studies. The data were needed to provide a check on the complex models that are used to predict such doses as a technical input into the proposed Uranium Fuel Cycle Standard. A report of this study has been published as "^{16}N Skyshine Survey of a 2400 MW(t) Nuclear Power Plant" (4).

Monticello Nuclear Generating Plant Dose Model Validation Study

A joint EPA/NRC field study was conducted at the Monticello Nuclear Generating Plant to obtain data for use in validating a dose model for estimating the external, whole body, cloud gamma dose to exposed populations. The model—after validation—will be useful in estimating dose to the population at other boiling water reactors with similar site and building characteristics.

Participants in the study included the EPA; Minnesota Department of Health; Northern States Power Company; and the NRC. A draft report has been prepared and reviewed and will be published in 1976.

G.E. Fuel Fabrication Plant

A field study was initiated in early 1974 at the G.E. Fuel Fabrication Plant north of Wilmington, North Carolina. The plant was chosen as being representative of the larger fuel fabrication facilities. The purpose of the study was to characterize the stack effluents and to acquire data from environmental surveillance at a facility on types of radionuclides discharged and significant environmental exposure pathways. These data will be used to validate dose models (and source terms) for use in future estimates of individual and population doses from normal operation of the plant. A draft report is now in preparation.

Harbor Study at Puget Sound

In cooperation with the U.S. Naval Ship Systems Command, the Office of Radiation Programs conducted a radiological survey at the Puget Sound Naval Shipyard in Bremerton, Washington. The purpose of this study and other previous studies of ports servicing nuclear powered ships was to locate, identify, and measure any radionuclides in the port or its environs due to nuclear ship activity. The data would then be analyzed to assess any hazard to the general population in the vicinity of the port. The field study conducted in November 1974 and the subsequent laboratory analysis of samples and data showed no significant levels of radioactivity due to nuclear powered ships. A draft of the study report has been prepared for review and publication is planned for 1976.

Browns Ferry Nuclear Power Plant

A joint study at the Browns Ferry Nuclear Power Plant in northern Alabama was initiated in July 1975. Participants included the Alabama Division of Radiological Health, the Alabama Environmental Health Administration Laboratory, the Tennessee Valley Authority, and EPA.

The objective of the study is to design and evaluate an ambient radiation monitoring program for the vicinity of the plant. Radiation exposures due to airborne releases from the plant will be predicted using mathematical models for comparison with measured values. Pressurized ionization chambers (PIC's) and thermoluminescent dosimeters (TLD's) were placed at locations chosen by the participants in July 1975. However, the plant has been shut down since then and only background data have been gathered. The plant is expected to resume operation in early 1976 at which time measurements under normal operating conditions will begin. Special field measurements will also be made to assess radiation contributions from sources such at nitrogen-16 and gamma emitters in waste tanks.

PLANT SAFETY

Review of the Reactor Safety Study

Because the occurrence of a severe nuclear power reactor power reactor accident could cause the death and injury of persons and long-term contamination of the environment, EPA has always considered the risk of such accidents to be part of its environmental concerns. EPA's activities in this area are related either to preparedness for accidents or to assessment of accidents. Those activities related to the assessment of risks are either in review of individual nuclear facility environmental impact statements (EIS) or in generic studies and reviews.

One of EPA's principal efforts in generic reviews is its review of the report of the Reactor Safety Study (5). This report, titled "Reactor Safety Study, An Assessment of Accident Risks in U.S. Commercial Nuclear power Plants," WASH-1400 (NUREG-75/014), presents quantitative risk estimates produced by the study group under the direction of Professor Norman C. Rasmussen of MIT, after whom it is sometimes called the "Rasmussen Study." The effort was initially sponsored by the U.S. Atomic Energy Commission and, after January 1975, by the U.S. Nuclear Regulatory Commission. The Reactor Safety Study report, WASH-1400, was accorded an intensive review by EPA because it is the first really significant effort to quantify the risks of nuclear power and because, due to its depth of analysis and the large amount of specialized manpower involved, it is likely to remain the principal reference on the subject for some time. The draft version of WASH-1400 was issued in August 1974, and EPA issued comments on it dated November 27, 1974 to the AEC and August 15, 1975 to the NRC. These comments, together with the report of EPA's contractor, Intermountain Technologies, Inc., have been issued as an EPA report (6). The principal points of EPA's review are:

(1) Greater emphasis should have accompanied the risk comparisons to disclaim any judgement on the acceptability of the risks.

(2) The general methodologies and rationale developed in the study to determine risk levels appear to provide a meaningful basis for obtaining useful assessments of accident risks of nuclear power plants; the methodology should be refined further and given wider application. Among the suggested future applications are off-shore power plants, HTGR's and LMFBR's.

(3) In general, the results are not sensitive to changes in the analysis of any particular accident event sequence because there are such a great number contributing to the overall results.

(4) Some of the consequence modeling assumptions with regard to evacuations and health effects tend to cause underestimates of the health effects. These could affect the overall risk estimates.

(5) Specific areas that could be significant and needed better support for the results presented were the BWR transient-withcut-scram accidents, and the failure pressure for the PWR containment.

(6) Editorial problems, inconsistencies, errors, omissions, and incomplete explanations were evident in many parts of draft WASH-1400.

(7) The application of the results from the Surry 1 PWR to the overall PWR population may involve greater uncertainties than the draft WASH-1400 suggests.

(8) The core meltdown and containment response analyses were found to contain many oversimplifying assumptions deserving more justification.

(9) Several areas were found which appear to be improperly or incompletely considered but for which insuffcient information is available to determine quantitatively their risk impact. These areas include human reliability, common mode failure quantification, some aspects of design adequacy, and techniques for calculating the results of small pipe breaks in PWR's.

It should be noted that EPA neither accepted nor rejected draft WASH-1400's numerical values of risk, but called for modification and information additions to certain aspects of the report. EPA pointed out that the report presents only the risk from severe accidents at some nuclear power plants, and that the overall risk from nuclear power includes contributions from normal operations of power plants, from the rest of the fuel cycle and from sabotage and terrorist activities.

The final version of WASH-1400 (7) was issued to Congress on October 30, 1975, in time to be taken into consideration in hearings on the Price-Anderson extension. It is being reviewed by EPA and Intermountain Technologies, Inc., with regard to revisions from the draft which possibly affect EPA's earlier findings. Because the section on calculation of accident consequences has been completely revised in the final vision, it is receiving particular attention. This review is to be concluded in the spring of 1976.

Risk Assessment Methodology

As society develops a capability to estimate risks in quantitative terms, certain related problems acquire more importance. One of these is understanding the degree of acceptance of different types of risks by the public and the reasons for acceptance of different risk levels. Another problem is that of establishing criteria to be used by regulatory agencies as bases for their regulatory activities, taking into proper consideration the risks associated with the industries being regulated. A risk assessment methodology adequate to handle these problems must incorporate more than accident consequences and probabilities.

Risks from Other Sources

In order to treat the risk from nuclear power properly, so that it may be considered in the regulation of the industry, it is necessary to know not only the risk in quantitative terms, but also the associated benefits, how the public regards the risks, how they compare to other risks, and what the alternatives are, including their associated risks. To provide some of the background information, EPA has sponsored research resulting in two reports. One of these, titled "The Consequences and Frequency of Selected Man-Originated Accident Events," (8) is a listing and classification of accidents in the United States in the period 1953–1973, causing ten or more fatalities, or thirty or more injuries, or three million dollars or more in property damage. The second, titled "Risk Assessment of Storage and Transport of Liquefied Natural Gas and LP-Gas,"(9) shows that this non-nuclear technology also has a potential for unlikely accidents with severe consequences. These reports provide information on risks in our society which is relevant to the understanding of risk and its acceptability.

WASTE MANAGEMENT

Nuclear Waste Disposal

Activities to meet the problems of radioactive waste disposal accelerated during 1975. As reported in last year's review, ERDA deferred earlier plans to develop an interim retrievable surface storage facility and is concentrating on methods for long term waste disposal. Planning and evaluating waste management has not been confined to ERDA, and recently interagency cooperation has been formalized for some activities in this subject. Meanwhile, the inventory of radioactive waste continues to grow and has become a subject of increasing concern. The operation of a nuclear reactor generates wastes in the quantities typified by the fuel cycle shown in Figure 3.3. At present, the cycle is open, and so the fuel expended in a reactor is stored to await reprocessing.

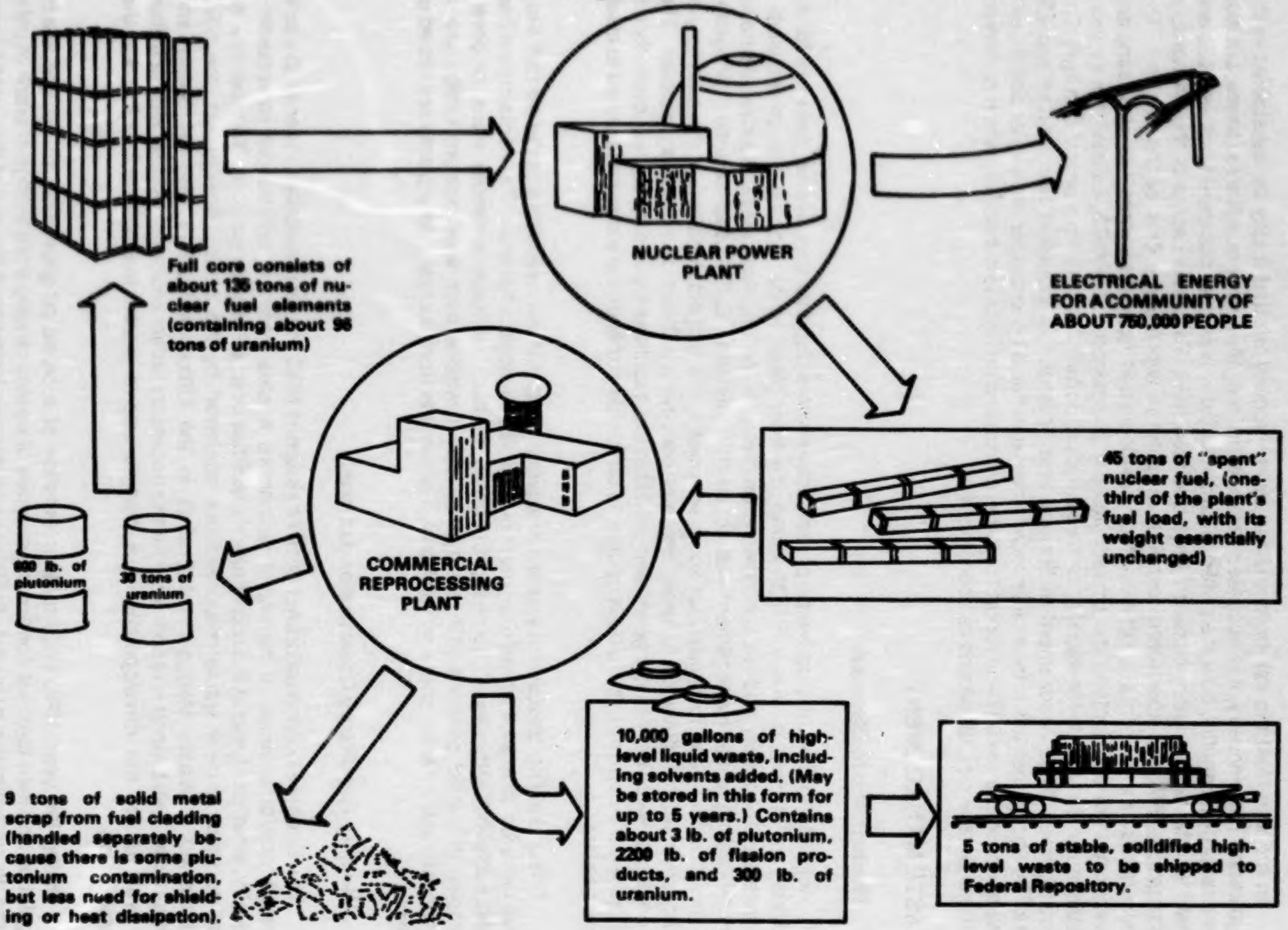
The underlying objective of waste management is to contain radioactive materials until they have decayed to a level where they present negligible biological hazards. This containment has been achieved, with varying degrees of success, by burial, storage in remote areas, or ocean dumping in sealed containers. Presently, radioactive wastes from weapons production are in interim storage in tanks, some of which leak, and wastes from nuclear power plants are stored at the plant.

Nuclear Regulatory Commission Actions

The Energy Reorganization Act of 1974 assigned NRC the responsibility to license the safe storage and/or disposal of high-level radioactive wastes from the commercial reprocessing industry, whether stored at the reprocessor's facilities or at a Federal repository. To meet this, as well as other nuclear waste responsibilities conferred by the Atomic Energy Act, the NRC established a Waste Management Branch in the Office of Nuclear Material Safety and Safeguards. This Branch is responsible for the necessary safety analyses and licensing activities as well as for the development of a comprehensive waste management policy for the Commission.

During the year, NRC undertook preparation of a broad program plan for nuclear waste regulation and management concerning all types of wastes ranging from tailings at uranium mills to the decontamination of nuclear facilities upon decommissioning at the end of their useful lives. Scope of the program will include standards development, backup research, and the licensing

Figure 3.3


Full core consists of about 135 tons of nuclear fuel elements (containing about 96 tons of uranium)
NUCLEAR POWER PLANT
ELECTRICAL ENERGY FOR A COMMUNITY OF ABOUT 750,000 PEOPLE
45 tons of "spent" nuclear fuel, (one-third of the plant's fuel load, with its weight essentially unchanged)
COMMERCIAL REPROCESSING PLANT
600 lb. of plutonium
30 tons of uranium
9 tons of solid metal scrap from fuel cladding (handled separately because there is some plutonium contamination, but less nued for shielding or heat dissipation).
10,000 gallons of high-level liquid waste, including solvents added. (May be stored in this form for up to 5 years.) Contains about 3 lb. of plutonium, 2200 lb. of fission products, and 300 lb. of uranium.
5 tons of stable, solidified high-level waste to be shipped to Federal Repository.

THE FUEL CYCLE ASSOCIATED WITH 1 YEAR'S OPERATION OF A TYPICAL 1000 ELECTRICAL-MEGAWATT NUCLEAR POWER PLANT.

actions required to protect public health and safety in all aspects of the handling, treatment, shipping, storage and disposal of nuclear wastes.

Under current NRC regulations, high-level liquid radioactive wastes resulting from fuel reprocessing operations must be solidified within five years of generation and shipped to ERDA within another five years for storage or disposal. NRC is charged by law with making licensing decisions on all storage and disposal facilities. The NRC is developing detailed standards and performance criteria for high-level waste disposal to help guide ERDA's waste management research and development program, while providing flexibility to include any additional options that may be developed as the program progresses.

Status of Low-Level Waste Disposal

At present, low-level waste disposal is the only form of waste disposal actively being accomplished. The general method of such disposal in this country and abroad has been burial in shallow trenches. There are six commercial shallow land burial facilities in the U.S. They are located at Barnwell, South Carolina; Beatty, Nevada; Maxey Flats, Kentucky; Richland, Washington; Sheffield, Illinois; and West Valley, New York. Similar burial facilities were established at five Federally-operated sites located at Idaho National Engineering Laboratory, Idaho; Hanford Facility, Washington; Los Alamos Scientific Laboratory, New Mexico; Oak Ridge National Laboratory, Tennessee; and Savannah River Plant, South Carolina. At each of these sites a monitoring program is carried out to detect migration of the buried radioactive materials so that corrective action can be taken if necessary to protect public health and safety.

What are these low-level wastes? It has been estimated (10) that 70 percent by volume of these wastes are paper, and that the density of the total waste would be about 10 lbs/ft^3. As well as paper, cleanup materials and absorbed liquids, packing, broken glassware, plastics, protective clothing, radioactive carcasses of experimental animals, and contaminated equipment are buried.(11) Depending upon the source and type, the wastes are shipped to the sites in 55-gallon steel drums or wooden or cardboard boxes for burial.

EPA has recently inspected two of the commercial burial sites. Both Maxey Flats and West Valley have not performed as expected. Migration of radioactivity from the burial trench has been detected at both these sites and at the Federally-operated site at Oak Ridge. The EPA studies indicate that the following sequence occurs:

- the wastes were buried in large trenches and covered with earthen caps
- rain soaked through the caps, filled the trenches, and soaked the wastes
- the water leached the wastes
- the leachate, containing radioactivity, overflowed the tranch or seeped through the ground.

A summary of activity at these sites is given in Table 3.2

Clearly, the level of precipitation affects the suitability of a waste disposal site. Other things being equal, arid sites are best. The "other things," however, are complex to evaluate, including soil porosity, hydrology, and seismic risk. With these uncertainties, surveillance is essential at any burial site.

At West Valley, tritium and strontium 90 were found in the leachate. The water has been diverted to a holding lagoon, where it is being treated. As at Maxey Flats, only traces are involved, but Nuclear Fuel Services closed the burial site in the spring of 1975 and is studying ways to control seepage. Low-level radioactive wastes generated in the eastern U.S. now are buried only at the Kentucky, Illinois and South Carolina sites.

TABLE 3.2

CHARACTERISTICS OF RADIOACTIVE WASTES BURIED AT THE MAXEY FLATS AND WEST VALLEY BURIAL FACILITIES

	Maxey Flats (Burial began 1973)	West Valley[1] (Burial began 1964)
Volume (cubic meters)	104,000	64,000
By-Product Material (curies)[2]	1,638,000	386,000
Special Nuclear Material (grams)[2]	349,000	52,000[3]
Source Material (pounds)[2]	158,000	986,000
Solidified Liquid Wastes	2,250,000	-0-

[1] Burial operations were halted in 1975.

[2] Includes radioisotopes produced in reactors, special nuclear material (plutonium and enriched uranium), source material (uranium and thorium) are defined in 10 CFR 20.

[3] Further burial of plutonium-239 was prohibited in 1974.

Spent Fuel Storage

There are, at present, no commercial plants operating in the U.S. to reprocess spent nuclear fuel. As a result, there is no high-level waste being generated for disposal. This material is still locked into the fuel elements taken from nuclear reactors and awaiting reprocessing. The storage of spent fuel elements is beginning to become a problem. In 1975, ERDA issued a report(12) on the situation. With the assumption that present storage capacity on-site at the power plants will be augmented by expansion of Nuclear Fuel Services' storage basin at West Valley, New York, by the end of 1976 four reactors will require additional storage beyond this to accommodate scheduled fuel discharges. Assuming no further increase in storage, the report finds 82 reactors will be short by 1985.

Because of the continuing building up on spent fuel in storage pools, owners of the three fuel reprocessing plants (none operating, except for storage) – located in New York, Illinois and South Carolina – have applied to NRC for licenses either to expand storage facilities already in operation or, in one case, to operate the storage basin at the site before completion of the entire plant. In addition, during 1975, four utilities applied to NRC for approval of storage capacity increases at their individual nuclear power plants – Point Beach in Wisconsin, Indian Point Unit 2 in New York, La Crosse in Wisconsin, and Maine Yankee.

In September, NRC announced that it would prepare a generic environmental impact statement on storage of spent fuel from light-water reactors, and would continue to act on storage license applications while the statement is being prepared.

Storage of spent fuel is regarded as an interim solution. On a long-term basis, spent fuel must either be reprocessed to recover the valuable uranium and plutonium for recycling in new reactor fuel, or managed as radioactive waste.

Crowding schemes involve redesign of the spent fuel storage pool so it will accommodate more fuel elements, still function to remove the heat generated, and not risk startup of a chain reaction. Neutrons may be absorbed by installing steel cells around the fuel elements; other ways of averting chain reaction are soluble poisons and redesign of pool configuration.

Barnwell Fuel Receiving and Storage Station

The NRC DEIS for the Barnwell Fuel Receiving and Storage Station (BFRSS) was issued during May 1975. The purpose of the DEIS was to allow Barnwell to receive and store spent fuel from nuclear power reactors. The need to find additional storage capacity for spent fuel was determined to be serious during 1975. Projections were made that the situation was becoming critical and the potential for shutting down power reactors was discussed as a real possibility. Licensing the Barnwell plant to receive and store spent fuel would help in alleviating the problem.

EPA concluded that more information was needed to reach a decision on the environmental impact of BFRSS. In particular, no information was presented as to whether or not alpha waste will be generated nor what quantities might be generated. In this regard it was also not clear as to whether the proposed shallow land storage area could be found acceptable for storage of alpha contaminated waste. With regard to liquid discharges, no information was presented to support the recommended license condition that would limit liquid waste discharge concentrations to 15% of the RCG's listed in 10 CFR 20.

EPA also found that the facility can be operated in compliance with applicable Federally approved State water quality standards and the requirements of the Federal Water Pollution Control Act of 1972, as amended. However, under the requirements of the Safe Drinking Water Act, the facility may be subject to a well injection permit for the seepage from the Carolina Bays and from Beacon Pond.

High-Level Waste Management Plans

Eventually, of course, the spent fuel must be reprocessed to recover uranium-235 and plutonium. The fission products must then be concentrated as high-level waste and disposed of. Plans for the preparation of this high-level waste and its eventual disposal are in the formative stage.

Currently, no reprocessing plants are operating in the United States. The Nuclear Fuel Services reprocessing plant at West Valley, New York, operated until late 1971 when it shut down for modifications and expansion. It is scheduled to resume in 1983. The General Electric Company, Midwest Fuel Recovery Plant in Morris, Illinois, has indefinitely postponed its 1974 schedule startup because of technical problems. The Allied-General Nuclear Services plant near Barnwell, South Carolina, is scheduled to begin operations in 1977–1978.

The form in which the high-level waste is produced will have a bearing on the case of disposal. Storage as a liquid, in a liquid waste storage tank, has been proposed by Nuclear Fuel Services and Allied-General Nuclear Services. However, Federal Regulations require that the liquid be transformed to a solid form within 5 years after reprocessing.

A waste management system being studied involves vitrification of the high-level radioactive wastes. Nuclear Fuel Services has started with the French St. Gobain technique for dispersing the wastes uniformly through a glass matrix, but is currently working on a new process which produces a glass block about 10 ft. high and 14 to 15 in. in diameter, weighing under a ton. Encased in stainless steel, the block can be shipped in standard fuel shipping casks.

In Great Britain similar plans for high-level waste vitrification are underway. The British Nuclear Fuels Ltd. originally planned to start construction in July of a pilot plant at Windscale to vitrify wastes, which are accumulating at a rate under 150 cubic meters a year. But controversy over who should pay for development of the process has delayed the construction.

A key problem is the disposal of the high-level wastes once they are stabilized. ERDA is studying the concept of a geological disposal pilot plant. Ultimately, a permanent geologic disposal facility, a storage facility for intermediate-lived gaseous wastes, and a disposal facility for long-lived gaseous wastes will also be needed. In 1975, ERDA restarted a program leading to the construction of a pilot disposal facility for transuranic wastes in bedded salt in southeast New Mexico. Programs on solidification and packaging of high-level waste are concurrent, and sealed canisters of waste for disposal will be used to study the disposal capabilities of bedded salt in this pilot facility.

Facilities for intermediate level and long-lived gaseous wastes are still in the conceptual stage. Decisions to construct these facilities may not be made until 1982 for the former and 1984 for the latter. In previous reprocessing activity, the long-lived gaseous wastes were released to the atmosphere. Both EPA and NRC are considering regulations for these gases (tritium, krypton-85, iodine-129, and carbon-14 as carbon dioxide are the principal ones). The regulations may prevent their release, hence there is need for technology to stabilize the gases for storage.

Low-Level Radioactive Waste

An unavoidable product of nuclear power generation, low-level radioactive waste results from the almost-complete removal of radioactive isotopes, by ion exchange resins, evaporators, etc., from the planned environmental releases due to normal plant operation. Under present Federal and State regulations, these wastes can be disposed of in shallow land burial grounds, operated under an NRC or State license. Since the wastes can contain appreciable quantities of very long-lived radionuclides, precautions must be elaborate and even so, the acceptability of burial is questionable. Several studies are being conducted by EPA, either in-house or by contract to investigate various facets of this problem, and are discussed below:

(1) The New York State Energy Research and Development Authority and EPA are presently engaged in a contract to conduct an investigation of the radioisotopic makeup of typical LWR generated ion exchange resins or sludges and evaporator concentrate wastes at two to four typical existing PWR and BWR reactors. The wastes will be analyzed for both short and long-lived alpha, beta, and gamma ray emitting radionuclides.

(2) A study is being conducted by the Office of Radiation Programs, to examine radioactive wastes received at commerical burial sites which are generated by light water power reactors (LWR) and supporting fuel cycle facilities.

Using operating experience data, this study attempts to:

Identify the types, source, and amounts of this material from the LWR fuel cycle.

Compare the quantities shipped from the LWR fuel cycle to burial site receipts in order to determine the magnitude of the LWR fuel cycle contribution.

Develop a realistic basis for projections of the growth of this material as a function of LWR generating capacity growth.

The nature of low-level solid wastes generated at each fuel cycle facility type and the method of disposal is being determined. Those facilities which ship wastes to commercial burial sites are identified. Estimates are made to related annual quantities of waste shipped to facility throughput of uranium. A composite or model fuel cycle is used to identify solid waste quantities generated in support of an annual fuel requirement for a 1000 MWe LWR. The model fuel cycle and annual fuel requirement concepts, as developed and used in studies by the former AEC and by EPA, form a convenient basis for comparing environmental quantities from different fuel cycles and as a basis for projecting future quantities.

The report will follow the general practice of using a 1000 MWe LWR operating at 80 percent load factor producing 7 x 10^9 kwhr of electricity at the bus bar. The fuel cycle throughputs will be expressed in metric tons (MT) of uranium for the composite fuel cycle and will be scaled on a reactor operating at 32 percent thermal efficiency.

(3) EPA has funded efforts by State licensing agencies to perform annual inventories of quantities of waste materials received at the commercial burial sites. Results have been published for 1962 through 1973 and efforts are currently underway to obtain the 1974 and 1975 inventory results. Waste volume projections are of interest in examining future burial capacity needs as a function of nuclear industry growth. Previous projections of low-level solid wastes have either

been based on projections of burial site receipts or on computations of quantities of waste radionuclides produced in reactors per unit of electricity generated.

An attempt has been made to gather operating experience data from other fuel cycle facilities and to update summaries of reactor operating experience to include information from 1974. Summaries of radwaste shipments from operating reactors for 1974 were obtained from semiannual operating reports to the NRC prepared by the utilities, supplemented, in some cases, by direct queries to the utilities. Direct queries were made to operators of other fuel cycle facilities and various NRC and State officials concerning radwaste practices at these facilities.

The main emphasis in this report will be on volumes of waste material shipped to commercial burial sites. For present purposes, the use of this criterion avoids the problem of resolving the various definitions of what is meant by low-level radioactive waste. The intent herein is to include all materials from the fuel cycle, including reactors, which are disposed of at the commercial sites.

(4) During 1975, EPA's Office of Radiation Programs contracted for a study of the buildup and decay of actinide and daughter acitivities in HTGR fuels and waste. Quantities of actinides in spent fuel, high activity waste and recovered U-233 are presented over five time periods for HTGR core loads, recycle of mixed U-233 and U-235, and recycle of LWR discharge plutonium in an HTGR. The information generated in this contract report for the HTGR fuel cycle is of similar format to that previously generated in a contract report(13) for LWR and LMFBR fuel cycles.

EPA has received the final contract report "Significant Actinide and Daughter Activities from the HTGR Fuel Cycle"(14). The results of this report will be used in the development of technical information for use by the Office of Radiation Programs in its standard setting activities and in its reviews of environmental impact statements for facilities in the HTGR fuel cycle. EPA is currently preparing the report for publication with duplication and distribution of the report expected for early 1976.

Ocean Dumping

Domestic Activities

(1) Permit Program – With the passage of the Marine Protection, Research, and Sanctuaries Act of 1972 (PL92–532) EPA was given a statutory responsibility to administer a permit program controlling ocean dumping of all pollutants including radioactive materials not expressly prohibited from disposal under the Act; prohibited materials include high-level radioactive wastes and radiological warfare agents. The Office of Radiation Programs developed a general policy of containment for any radioactive wastes which might be considered for future disposal in order to prevent any dispersion and dilution in the oceans.(15,16)

To date one application has been received and reviewed (U.S. Air Force, 1975). This special permit application was returned to the USAF with a request for additional information which has not been received. Two informal requests have been reviewed although specific permits were not submitted by the requesters— one from the U.S. Navy for low-level reactor wastes, the other from the Defense Nuclear Agency concerning the radioactive debris on Enewetak Atoll. No permits have been issued by EPA for ocean disposal of radioactive wastes because of the lack of adequate information on the potential fate of the packaged radioactive materials in the ocean.

(2) Field Studies – The Office of Radiation Programs (ORP) has initiated field studies of past-used U.S. low-level ocean dumpsites. Two sites received the majority of the wastes dumped between 1946–1970:

East Coast – approximately 120 miles east of the Maryland-Delaware coast at a depth of 2800 meters.

West Coast – forty miles west of San Francisco, California near the Farallon Islands; consists of two sub-sites at 900 and 1800 meters.

ORP has conducted submersible operations at all three depths listed above and found packaged radioactive wastes. Extensive photographic documentation was made and sediment samples were taken very close to the containers to determine such factors as hydrostatic pressure effects, benthic species abundance, and types of radionuclides released. An Operations Report has been prepared on the 1974 Farallon Islands 900-meter site and technical reports of the three depth surveys will be issued.

A paper has recently been issued (18) summarizing some of the results of the sediment radioanalyses, current-meter measurements, commercial fish species observed, and condition of the waste packages at the dumpsite depths of 900 meters and 2800 meters in the Pacific and Atlantic respectively. Plutonium-239, 240 contamination was detected in surface sediments forty miles west of San Fransicso at the 900 meter depth in concentrations ranging from 2–25 times higher than the maximum expected concentration that could have resulted from weapons testing fallout. Plutonium-238 was also measureable.

In the 2800 meter Atlantic dumpsite, cesium-137 was measured in sediments at concentrations ranging from 3–70 times higher than the maximum expected fallout concentration. Most of this contamination was associated with radioactive waste containers that were visibly breached by corrosion or hydrostatic pressure effects.

International Activities

In November 1972, the United States signed the International Ocean Dumping Convention, and this was ratified in April 1974. The convention thereby became a treaty, to be intered into force in October 1975. Under the Ocean Dumping Act of 1974 (P.L. 92–532), EPA is responsible for regulations and criteria to meet this treaty. Criteria, published in the *Federal Register* (October 15, 1973) include a policy of placing wastes to be dumped in containers such that the waste will decay to environmentally innocuous levels within the lifetime of the container and its inert matrix.

Since 1973 ORP has been the U.S. representative to the International Atomic Energy Agency's (IAEA) panel of experts on ocean dumping of radioactive wastes. The IAEA was charged with the responsibility to develop specific recommendations regarding ocean dumping of all radioactive wastes pursuant to the International Ocean Dumping Treaty (ratified in August 1975).

Most recently ORP participated in an IAEA meeting in Vienna, Austria in February 1975, to review the ocean dumping dispersion model used to develop the IAEA recommendations (17). EPA-ORP was instrumental in bringing about stronger environmental safeguards in the dispersion model and is working towards the incorporation of these safeguards into the basic IAEA recommendations on ocean dumping.

High-Level Waste

One of the major environmental concerns associated with the projected increase in nuclear power generation is the handling and disposal of high-level radioactive waste. Periodically, a portion of the nuclear reactor's core must be removed for reprocessing of fuel elements to remove the accumulated radioactive fission products and recover the remaining fuel for reuse. The fission product waste is the most significant of the fuel reprocessing plant residuals and includes radioisotopes having very long half-lives. This high-level waste must eventually be placed in long term storage repositories which prevent entry into the environment for up to tens of thousands of years.

There have been several studies (18,19,20) of radioactive waste management alternatives which describe most of the disposal concepts which have been proposed and discuss advantages and disadvantages of each. The concepts studies may be divided into the following categories:

1. Disposal in terrestrial locations

    a. In geologic settings on land
    b. In the seabed
    c. In ice sheets

2. Disposal in space

3. Elimination by transmutation

Assessment methodology, that is both independent and flexible, is being conducted by EPA for the evaluation of the various long term waste disposal methods and management options. State and Federal regulatory and R&D agencies must be in a position to evaluate proposals for waste management activities in the course of carrying out their assigned functions (i.e., to protect public health and safety, to protect resources, and to insure adequate financial compensation for any long term risk involved). EPA's current project in this area is to assess and evaluate the national high-level radioactive waste management program, so that the long term adequacy of provisions for burial is assured and that total cost of radioactive waste handling and disposal is minimized. Full implementation of the results of this study will aid EPA and others in evaluating waste management programs to insure adequate financial compensation for any short term as well as long term risks involved.

A radioactive Waste Management Systems Model is being developed under an EPA contract to assist in performing this assessment. The fuel reprocessing plant, its high-level radioactive waste (residuals) discharges, transport and disposal of these wastes in a region, and the environment, comprise the Radioactive Waste Management Systems Model. There are four parallel paths in the model contributing to charges assessed against the residuals. Each path represents a phase in the management sequence and includes a release or fault tree model, an environmental model and an economic model which calculates damage costs. The first phase is residuals treatment taking place at the reprocessing plant, since the treatment is performed on-site. Following treatment, the next phase is transport to the repository. The repository operations phase involves receipt of shipments, any preparations or assembly required, and the placement into the underground storage zone. The duration extends only until the receipt of shipments ceases and operations terminate. The long term storage phase applies to wastes after placement underground in one of the several concepts for a long term storage repository.

UNITED STATES NUCLEAR NAVY

As of March 1975, there were 105 nuclear submarines and seven surface ships in the U.S. Navy with authorization for a total of 148 nuclear active U.S. warships. There are also 6 land-based prototype reactors in operation. The naval program is the single largest reactor program in the country (21).

Available figures for 1974 showed that the total volume of water discharged by the U.S. Navy in restricted waters from 111 ships, 9 shipyards, 11 tenders and 2 submarine bases was less than 10,000 gallons. This water contained less than 0.002 curies of radioactivity excluding tritium. The total tritium released into harbors within 12 miles was less than one curie. The solid wastes are packaged in approved containers and shipped to burial sites licensed by the NRC (or by a State under agreement with the NRC) in compliance with the Department of Transportation (DOT) and NRC. In 1974 this amounted to 62,000 cubic feet and about 387 curies of radioactive material. This solid waste becomes numbered among items destined for ultimate disposal; thus, it contributes to the waste management problem. The Navy concluded in their annual environmental report that radioactivity associated with their nuclear program has had no significant or discernible effect on the quality of the environment.

References

1. U.S. Nuclear Regulatory Commission, "Annual Report 1975" Pursuant to the Requirements of Section 307 (c) of the Energy Reorganization Act of 1974. pgs. 43–46.

2. U.S. Environmental Protection Agency, Draft Environmental Statement, "Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle," For a Proposed Rulemaking Action (May 1975)

3. U.S. Environmental Protection Agency. Radiological surveillance study at the Haddam Neck PWR nuclear power station, EPA-520/3–74–007. Office of Radiation Programs, Washington, D.C. (December 1974).

4. U.S. Environmental Protection Agency. ^{16}N skyshine survey at a 2400 MW(t) nuclear power plant, EPA-520/5–75–018. Office of Radiation Programs, Washington, D.C. (December 1975).

5. U.S. Atomic Energy Commission, *Reactor Safety Study, An Assessment of Accident Risks in U.S. Comercial Nuclear Power Plants,* WASH-1400, U.S. Atomic Energy Commission, Washington, D.C. 20545 (draft August 1974).

6. U.S. Environmental Protection Agency, *Reactor Safety Study (WASH-1400): A Review of the Draft Report,* EPA-520/3–75–012, U.S. Environmental Protection Agency, Washington, D.C. 20460, (August 1975).

7. U.S. Nuclear Regulatory Commission, *Reactor Safety Study, An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants,* WASH-1400 (NURG-75/014), U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, (October 1975).

8. CONSAD Research Corporation, *The Consequences and Frequency of Selected Man-Originated Accident Events,* EPA-520/3–75–016, U.S. Environmental Protection Agency, Washington, D.C. 20460, (August 30, 1974).

9. J.A. Simmons, SAI Services, *Risk Assessment of Storage and Transport of Liquefied Natural Gas and LP-Gas,* EPA-520/3–75–015, U.S. Environmental Protection Agency, Washington, D.C. 20460, (November 25, 1974).

10. Morton, R.J., "Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities," U.S. Atomic Energy Commission, WASH-1143 (1968).

11. Meyer, G.L., "Recent Experience with the Land Burial of Solid Low-Level Radioactive Wastes," U.S. Environmental Protection Agency, presented to the IAEA Symposium on Management of Radioactive Wastes, March 1976.

12. "LWR Spent Fuel Disposition Capabilities, 1975–1984," U.S. Energy Research and Development Administration, March 1975.

13. Heeb, C.R. and E.T. Merrill, *Significant Actinide Activities in the LWR and LMFBR Nuclear Fuel Cycles*, U.S.EPA Contract Report, EPA-520/3–75–006, October 1974.

14. Simmons, G.L. and M.L. Gritzner, *Significant Actinide and Daughter Activities from the HTGR Fuel Cycle*, September 5, 1975, being prepared for publication as a U.S.EPA Contract Report.

15. *Federal Register*, October 15, 1973. Title 40, Chapter 1, Subchapter H; Ocean Dumping Final Regulations and Criteria.

16. U.S. Environmental Protection Agency. *A Survey of the Farallon Islands 500-Fathom Radioactive Waste Disposal Site* (Operations Report), Technical Note ORP-75–1, December 1975.

17. Dyer, R.S., "Environmental Surveys of Two Deepsea Radioactive Waste Disposal Sites Using Submersibles," U.S. Environmental Protection Agency; presented at the joint IAEA/NEA Symposium on the Management of Radioactive Wastes from the Nuclear Fuel Cucle, IAEA, Vienna (1976) in press.

18. High Level Radioactive Waste Management Alternatives, WASH-1297, USAEC, May 1974.

19. High Level Radioactive Waste Management Alternatives, BNWL-1900, 4 volumes, May 1974.

20. Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle, ERDA-76–43, 5 volumes, May 1976.

21. Rickover, Admiral H.G., "Naval Nuclear Propulsion Program, 1975, Hearing Before the Joint Committee on Atomic Energy," 94th Congress of the United States, First Session, Testimony given March 5, 1975.

MEDICAL, OCCUPATIONAL AND CONSUMER PRODUCT RADIATION— CHAPTER 4

MEDICAL X-RAYS

The Medical Radiation Problem

There has been marked increase in the number of diagnostic x-ray examinations performed in the United States over the last decade with estimated annual increases ranging from 1 to 4 percent (1). Two notable surveys of diagnostic radiology practice were the x-ray Exposure Studies of 1964 and 1970 conducted by the Food and Drug Administration (FDA) in cooperation with the National Center for Health Statistics (NCHS). Recently, FDA has released an interim report which shows some of the changes in diagnostic radiology practices which occurred from 1964 through 1970 (2).

Some of the more dramatic indications taken from this report were as shown below and summarized in Table 4.1:

(1) There was a 20 percent increase in the number of persons receiving one or more x-ray procedures from 108 million in 1964 to 130 million in 1970 while the population increased only 7 percent during the same period.

(2) There was a 22 percent increase in the number of x-ray examinations performed from 173 million in 1964 to 212 million in 1970.

(3) There was a 30 percent increase in the number of films exposed from 506 million in 1964 to 661 million in 1970.

(4) The average number of films per radiographic examination increased from 2.2 in 1964 to 2.4 in 1970.

(5) The percentage of thoracic examinations performed with two or more x-ray films increased from 31 percent in 1964 to 47 percent in 1970. This was attributed to the inclusion of lateral views for routine chest examinations.

(6) The mean ratio of beam area to film area for radiographs declined approximately 30 percent.

TABLE 4.1 TRENDS IN RADIOGRAPHIC DIAGNOSTICS

PERSONS X-RAYED	1964	108 MILLION
	1970	130 MILLION
X-RAY EXAMINATIONS	1964	173 MILLION
	1970	212 MILLION
FILMS EXPOSED	1964	506 MILLION
	1970	661 MILLION

The increased use of x-ray examinations can be explained in some measure by the increase in the U.S. population, as well as by improvements in the availability of medical care for older and poorer segments of society (Medicare and Medicaid programs). Most recently, the trends for patient exposure from specific radiographic examinations have been examined by the Nationwide Evaluation of X-Ray Trends (NEXT) a survey program which is supported by the Conference of Radiation Program Control Directors and the Food and Drug Administration. The NEXT program is an on-going program and its annual reports provide the most recent survey data for the measured exposures for selected radiographic views. The objectives of the NEXT surveys are to establish trends in effectiveness of radiological health programs and to identify the optimum components of an x-ray installation survey. NEXT reports on "All States" representative surveys are produced semi-annually for twelve selected radiographic views. The radiographic views currently being surveyed and the mean exposures for the views taken from the last two annual reports are listed in Table 4.2. This table indicates that the only change in mean ESE, which is statistically significant at the 95% confidence level is a decrease for the thoracic spine examination.

A clearer perspective of the extent of medical and dental uses of x-rays for diagnostic purposes is evidenced by the fact that over 90 percent of current man-made exposure is due to such x-ray examination and further that over 50 percent of the United States population receives a radiographic examination annually. It should be noted that this in itself does not necessarily establish that medical exposure is excessive, because medical uses constitute a purposeful application of radiation on humans as contrasted with those uses in which radiation exposure is an unwanted by-product (as in nuclear reactor operations).

The attendant benefits from the use of x-rays for medical or dental diagnosis are well recognized. However, there are reasons to believe that a significant proportion of the exposure received from these uses is unnecessary.

TABLE 4.2

LIST OF NATIONWIDE EVALUATION OF X-RAY TREND SURVEY RADIOGRAPHIC VIEWS AND MEAN EXPOSURES AT SKIN ENTRANCE (ESE)*

Projection	Time Period 4 (7/1/73 to 6/30/74)		Time Period 8 (7/1/74 to 6/30/75)	
	Mean ESE	Standard Error	Mean ESE	Standard Error
Chest (P/A)	22	2	21	2
Skull (Lat)	317	123	273	43
Abdomen (A/P)	582	43	671	67
Retrograde Pyelogram (A/P)	682	163	726	73
Thoracic Spine (A/P)	961	91	594	110
Cervical Spine (A/P)	329	220	239	18
Lumbo-Sacral Spine (A/P)	943	193	757	68
Full Spine (A/P)	231	35	281	42
Feet (D/P)	214	150	209	60
Dental Bitewing (Post)	628	101	469	71
Dental Periapical	656	135	610	126
Dental Cephalometric (Lat)	28	6	42	15

*Weighted according to facility workloads.

The implications are clear; it is well recognized that any amount of exposure to ionizing radiation places incremental risks of either a somatic or genetic nature on the person so exposed. It is paramount then to establish whether current radiologic practices are performed at the maximum benefit to the patient while delivering the minimum exposure risk. To this end, there are a number of medical and scientific groups which generally agree that there is unproductive radiation exposure from medical x-ray uses that could, and should, be reduced.

Issues of Medical Radiation Use

The extent of usage of radiographic procedure as a routine part of diagnostic medicine has been noted and numerous warnings or cautions against unnecessary radiologic examinations have been issued. Patient exposures which are ten times higher than that needed to provide the required diagnostic information may occur in present day medical practice (3). In 1959 and again in 1966, the National Advisory Committee recommended to the Surgeon General of the Public Health Service that programs were advised to prevent the overuse of diagnostic x-ray examinations. More recently the Biological Effects of Ionizing Radiation (BEIR) Committee recommended that all examinations should be clinically justified and performed utilizing the most efficient and optimal techniques to obtain the required clinical information. Specifically the judgment of the BEIR Committee was that a significant reduction in patient exposure, "without loss of benefit" to the patient and "at relatively low cost could be accomplished". Likewise, Committee 3 of the International Council on Radiation Protection (ICRP) has concluded that, "there is a need to ensure that the advantages of diagnostic radiology are obtained with the minimum risk to the individual and to future generations.

The BEIR Committee concluded that as much as 30 percent of the patient exposure is due to use of less than optimal techniques and that nearly 10 percent of all exposure can be attributed to retake examinations. The BEIR Committee recommended, "Medical radiation exposure can and should be reduced considerably by limiting its use to clinically indicated procedures utilizing efficient exposure techniques and optimal operation of radiation equipment. Consideration should be given to the following:

1) Restriction of the use of radiation for public health survey purposes, unless there is a reasonable probability of significant detection of disease.

2) Inspection and licensing of radiation and ancillary equipment.

3) Appropriate training and certification of involved personnel. Gonad shielding (especially shielding the testes) is strongly recommended as a simple and highly efficient way to reduce the Genetically Significant Dose."

The BEIR Committee also stated, "that experts estimate that it appears reasonable that as much as a 50 percent reduction in the genetically significant dose (GSD) from medical radiology might be possible through improved technical and educational methods." A BRH study indicates that in 1970 the genetically significant dose was approximately 20 millirems per member of the U.S. population. Using the BEIR risk estimate translates this into 543 serious-health effects (genetically related) produced in 1970 to the U.S. population. It appears that half of these, or 272 serious-health effects, are produced annually due to poor radiological practice.

FEDERAL GUIDANCE

The responsibility for controlling medical and occupational exposure to radiation generating equipment and radioactive materials is divided between the Federal and State governments. Within the Federal government, the Environmental Protection Agency (EPA), the Department of Health, Education, and Welfare (DHEW), the Department of Labor (DOL), and the Nuclear Regulatory Commission (NRC) are responsible for protecting the public against the deleterious effects of ionizing radiation. The DHEW, pursuant to authority under the Radiation Control for Health and Safety Act (PL 90–602), has the major Federal responsibility for establishing equipment performance standards for electronic products which emit radiation.

The responsibility of providing Federal radiation guidance applicable to all Federal agencies now resides in the Environmental Protection Agency. This authority, which was previously vested in the Federal Radiation Council by the Atomic Energy Act (PL 83–274h), was transferred to the EPA by Reorganization Plan Number 3 of 1970. As a consequence, the EPA administrator is now charged (42 USC 2021h) to advise the President on radiation matters directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards. Other Federal agencies and the fifty State governments have complementary responsibilities to establish radiation protection regulations. The Public Health Service is authorized under the Public Health Service Act to conduct studies and carry out educational and training activities for protection of the public health. The DHEW has interpreted their broad authority to provide a basis for developing and recommending voluntary guidelines for use of medical radiation.

At present, the responsibility to control exposure due to diagnostic x-ray examinations is divided between the Federal and the State governments. Within the Federal Government, the Bureau of Radiological Health in the Department of Health, Education and Welfare has the responsibility of administrating the Radiation Control for Health and Safety Act. The Secretary of Health, Education and Welfare is required by the act to submit an annual report to the President for transmittal to the Congress. Under the Public Health Service Act, the Secretary of DHEW (with authority delegated to the Bureau of Radiological Health) has the responsibility to enact those regulations and recommendations which will ensure that the use of all electronically produced electromagnetic and sonic radiation (including x radiation) for medical diagnosis and treatment will cause patient exposures that are al low as reasonably achievable without sacrificing medical benefit. The Environmental Protection Agency under the authority of Reorganization Plan 3 of 1970 is mandated to advise the President on radiation matters affecting public health. However, no Federal laws, regulations, or guidance presently exist to ensure that the use of x-rays for medical diagnostic purposes will bestow patient exposures that are as low as might reasonably be achievable.

EPA Federal Guidance

The basic strategy of the EPA program to reduce public x-rays dosage is: 1) to carry out its Federal Guidance responsibility to assure that the benefits to patients from the use of medical x-rays are derived at minimum risk in Federal health care programs and Federal facilities by giving appropriate guidance to affected agencies, and 2) by way of example and publication of the results of such efforts to influence the private sector to give similar protection to the general public. No individual will be deprived of obtaining the necessary benefits of diagnostic radiology nor will any physician be inhibited from providing basic health care, but guidance will be given to eliminate unnecessary exposure.

EPA efforts will focus on decisions to prescribe x-rays and improving techniques of optimizing exposure when x-rays are taken. Attempts in the first area will be made to preclude circumstances such as routine examinations given before a doctor is seen, retakes when adequate x-rays exist in files or as result of poor technique, and unnecessary confirmation of diagnosis that is or can be made from non-radiological tests. A program has been undertaken to set a Federal example, an approach that is expected to be successful in reducing dose in all sectors. The goal of the guidance is to assure that the benefits to patients from the use of medical x-rays are derived at minimum risk in Federal health care facilities by giving appropriate guidance to the implementing agencies. To accomplish this, the Administrator, on July 5, 1974, formed an Interagency Working Group on Medical Radiation to develop guidance. This working group is made up of representatives from the military services and the Veterans Administration. (DHEW declined to participate in this effort.) Two subcommittees have examined potential dose reductions by improving prescription (Subcommittee on Prescription of Exposure to X-rays) and technic (Subcommittee on Technic of Exposure Prevention). The recommendations of these subcommittees and the full working group provide the basis for specific guidance to be developed by EPA for promulgation as Federal Guidance.

During 1975, Subcommittee on Prescription of X-Rays (SPEX) drafted a report on the ordering of diagnostic x-ray studies. The recommendations of this committee concerning the prescription aspects of diagnostic studies are currently under review by the Interagency Working Group and such recommendations when endorsed by the Working Group will be used by EPA as a basis to develop Guidance for diagnostic radiology. The SPEX report makes recommendations for prescription of x-rays in Federal health care facilities in the following broad categories:

1. Restriction of privileges to order general medical and dental x-ray examinations and general fluoroscopic examinations to those possessing medical and dental degrees who are eligible for licensure in the U.S. or properly trained personnel under their direct supervision; special fluoroscopy procedures and invasive studies could only be prescribed by those with sufficient training in specialities to interpret the results of such studies.

2. Elimination of routine examinations, unless clinical indications exist, for such circumstances as hospital admission chest x-rays, chest x-rays screening for tuberculosis, routine full mouth and bitewing dental radiographs, and mamography screening in asymptomatic women under age 35.

3. Involvement of diagnosticians, especially radiologists, in medical decisions requiring the prescription of diagnostic x-ray examinations by establishment of written policies on who can perform examinations, the number of views for standard examinations, and the need to keep the number of standard examinations to a minimum because such generalization tends to increase exposure for a given examination.

4. Requiring all fluoroscopic equipment for fixed Federal facilities to have image intensification; fluoroscopy in non-radiology specialties should be done with units with electronic image-holding features when practicable.

The Subcommittee on Technic Exposure Prevention (STEP) is currently developing its recommendations in x-ray technique. It is hoped that by the summer of 1976 their report will be completed. If such be the case, then it is expected that Federal Guidance for diagnostic radiographic procedures could be developed and instituted by early fall of 1976.

FDA Guidance

As previously noted, FDA's Bureau of Radiological Health establishes recommendations on optimum practices in medical radiology and conducts educational programs for medical radiation users under the authority of the Public Health Service Act, as amended by PL 90–602, under Title III, Part F, Subpart 3, Section 356. Under this authority BRH provides in-depth analysis, testing, validation, environmental, economic and clinical assessment and evaluation of its regulations and recommendations. BRH also provides implementation of its recommendations at Federal, State, professional and consumer levels in order to maximize their dose optimization impact. It has specific programs aimed at educating physicians and allied health users in the appropriate radiological health practices pertinent to their professions, including the ordering of x-ray examinations, their conduct and the interpretation of their results. The status of these guidelines are summarized below.

Model Regulations for States

A revised "Suggested State Regulations for Control of Radiation," has been published and distributed to State radiation control agencies for their use. The revision, essentially an update and expansion of the 1970 edition by the same name, was prepared by the Bureau of Radiological Health, the Atomic Energy Commission (AEC), and the Conference of Radiation Control Program Directors. The revised suggested regulations, often referred to as "model State regulations," reflect changes in National Council on Radiation Protection and Measurement guidelines, new amendments to AEC regulations, and electronic product radiation safety performance standards issued by the Bureau. They are intended primarily as guidance for State radiological health programs developing or amending their radiation control regulations. This is especially important because certain Federal laws, including the Radiation Control for Health and Safety Act, and Atomic Energy Act, require State regulations to be compatible with, identical to, or as effective as Federal regulations.

The current "Suggested State Regulations" covers three new areas: analytical x-ray equipment, particle accelerators, and notices, instructions, and reports to workers. The latter is related to Occupational Safety and Health Administration requirements. With the new subjects there is a total of ten parts to the model regulations. The others are general provisions, registration of radiation machine facilities and services, licensing of radioactive materials, standards for protection against radiation, radiation safety requirements of industrial radiographic operations, x-rays in the healing arts, and use of sealed radioactive sources in the healing arts.

This model regulation was developed so that the States could promulgate statutes compatible with each other and with the Federal government. Fifty States, the District of Columbia, and Commonwealth of Puerto Rico now have laws for regulation of ionizing radiation. A notice of availability of the regulations was published in the *Federal Register* Vol. 40, Number 136, dated July 15, 1975.

Guidelines on Radiation in Pregnancy

The Bureau of Radiological Health has announced plans to develop guidelines concerning exposure of women of childbearing age to ionizing radiation from medical diagnostic procedures. The announcement appeared in the December 15 *Federal Register*.

Exposure of the developing human embryo or fetus to ionizing radiation may result in certain deleterious effects, including an increased risk of childhood leukemia. The proposed guidelines will aim at reducing such risks by recommending procedures for radiological examinations of potentially pregnant women that will minimize unnecessary exposure of the fetus.

As presently conceived, the guidelines will provide recommendations to clinicians regarding exposure of possibly pregnant women to ionizing radiation from both x-ray examinations and nuclear medicine procedures. The Bureau presently is studying certain diagnostic x-ray and nuclear medicine practices to determine what actions may be taken to minimize fetal exposure.

Mammography Recommendations

The American College of Radiology (ACR) expert panel on mammography made four recommendations which were adopted, with slight modification, by the Medical Radiation Advisory Committee of BRH. The recommendations were made during a special session of the Advisory Committee convened to consider public health implications associated with the increased use of mammography in the U.S. and to provide guidance as to the BRH's role in this area. These recommendations are as follows:

1. Mammography—x-ray examination of the breast—should not be used routinely in "asymptomatic women" under the age of 35 to detect breast cancer. Asymptomatic women are defined as those "without complaint, without history, without physical findings, and without a strong family history of breast cancer." The recommendation against routine mammography examinations under the age of 35 is based on the low incidence of breast cancer in this age group and the decreased effectiveness of the procedure in detecting early cancer in the breast of the younger woman. This is because the breast tissue is firmer and more fibrous which may obscure early signs of breast tumors. The significance of the recommendation lies in recent reports that breast cancer screening centers are being set up for young women, for example, on college campuses.

The panel did not take a stand on the use of this screening procedure for women over 35. Rather, the panel stated "the issue of efficacy on routine mammogram examinations in asymptomatic women in the 35–50 age group is still in question and additional studies should be devoted to this area."

This work is underway in a large-scale breast cancer screening program sponsored by the American Cancer Society and the National Cancer Institute. The project, begun in 1973, will involve the examination of 270,000 women, none of whom have evidence of breast cancer, in 27 detection centers across the U.S. The aim of the project is to learn if current detection methods, such as physical examination, x-ray film mammography, and thermography, can spot cancer before the woman becomes aware of a breast lump.

2. The Bureau support the expansion of activities of the regional physics centers of the National Cancer Institute and the American Association of Physicists in Medicine, as well as State radiological health agencies, to make available on a national basis uniform dosimetry methodology for mammographic examinations. The physics centers, of which there are six across the country, provide dosimetry and calibration support services for the 27-center breast cancer detection study. The language of the recommendation as it now stands reflects an amendment offered by the Advisory Committee to include State agencies.

3. The Medical Radiation Advisory Committee appoint a liaison member to the American College of Radiology's Committee on Mammography and Diseases of the Breast.

4. The Medical Radiation Advisory Committee appoint a subcommittee on mammography, to include liaison members from the ACR Committee on Mammography and the American Association of Physicists in Medicine.

The Medical Radiation Advisory Committee forwarded the recommendations to BRH for its consideration. The Bureau Task Force on Mammography will develop an action plan based on the recommendations. This plan may include a guideline on the use of mammography for breast cancer detection.

Voluntary Guidance on Gonad Shielding

The Food and Drug Administration has proposed a guideline for the use of gonad shielding during medical diagnostic x-ray procedures. The proposal appeared in the *Federal Register*, September 16, 1975, and final publication is anticipated by June 30, 1976.

The recommendation is the first in a series of guidelines on medical radiation use being prepared by the BRH, and will be the first to be published in a new subpart of Title 21 of the Code of Federal Regulations set aside for voluntary guidelines and recommendations concerning electronic product radiation. The guidelines will be implemented through educational programs and cooperative activities with professional organizations.

Gonad shielding is accomplished by placing lead or lead-impregnated material between the x-ray source and the reproductive organs of the patient. Three types of specific area gonad shields, which cover an area slightly larger that the region of the gonads, are now in use: shadow shielding; flat, contact shielding; and shaped, contact shielding for male patients.

The proposal recommends that such shielding be provided when: (1) the gonads will lie within the primary x-ray field, or within close proximity (about 5 centimeters), despite proper beam limitation; (2) the clinical objectives of the examination will not be compromised; and (3) the patient has a reasonable reproductive potential.

Clinical techniques for testicular shielding are better established at present than those for ovarian shielding. Examples of examinations during which testicular shielding is recommended are those of the pelvis, hip, and upper femur. Depending on the size of the patient and the examination technique and equipment employed, male gonad shielding also may be warranted during other pelvic area x-ray procedures. Each facility, according to the proposed guideline, should evaluate its procedures, techniques, and equipment and compile a list of examinations for which testicular shielding should be routinely considered.

With regard to ovarian shielding, the guideline notes that its use is sometimes impractical because the exact location of the ovaries is difficult to estimate and the shield may obscure areas of diagnostic interest. Although the ovaries may be shielded during selected views in some examinations, little practical guidance is presently available on implementing the proposed criteria for females. The BRH is continuing to support efforts to develop such guidance. It is hoped that comments submitted in response to the proposed guideline will provide additional information on the appropriate use of ovarian shielding.

Recommendations for Qualifications of Medical Radiation Technologists

The FDA's Bureau of Radiological Health is forming a national committee of State and professional organization representatives to formulate *Recommendations for Qualifications of Medical Radiation Technologists*. Presently, there are a number of both governmental and professional organizations setting standards and qualifications for individuals working in the professions of diagnostic x-ray and nuclear medicine technology. Such standards are overlapping and, in some aspects, contradictory and incompatible. This Committee will produce a single set of recommendations in the areas of education, training, field-entry mechanisms and continued competence, which will be published in the *Federal Register*.

Quality Assurance Recommendations

The Quality Assurance program of the FDA's Bureau of Radiological Health is a major new approach to assuring that the maximum diagnostic benefits commensurate with minimum patient risk and cost are obtained from the use of diagnostic x-rays. The goal of this effort is to encourage the implementation of quality assurance programs in all diagnostic x-ray facilities. Such a facility program would include all actions taken to ensure that equipment, once manufactured and installed according to regulations, and operators, once trained, continue to produce consistently high quality radiographs at minimum cost and patient exposure. This involves:

(1) Quality Control monitoring techniques used in routine physical testing of the x-ray system to identify the need for corrective or preventive maintenance, and

(2) Quality Administration management actions to guarantee that the needed corrective measures are taken.

As a result of preliminary studies, conducted during 1975, FDA has determined that the issuance of Quality Assurance recommendations through the Federal Register is the most promising way to stimulate establishment of Quality Assurance Programs in diagnostic x-ray facilities. Work on the recommendations began in 1975 and will be advanced with a major program effort in 1976.

Other 1975 FDA program actions supporting the development of recommendations fell into two areas:

a. Provision of guidance to facilities wishing to implement quality assurance programs. Several program actions are in progress in this area.

> The Food and Drug Administration has initiated a program, in cooperation with the Public Health Service Hospital in Baltimore, to assess the results of a facility-based quality assurance program, carried out by hospital staff members, to assure consistent radiographic quality. The first phase of this program, completed in November of 1975, involved the collection of base-line data on parameters such as repeated x-ray examinations, radiographic film quality, and patient exposure. During the second phase various quality assurance procedures are being introduced into the hospital's radiology department and their impact in terms of reducing exposure while maintaining or improving film quality is being evaluated. The final product will be the development of a recommended quality assurance protocol for use in any hospital desiring to establish a facility-based program. It is expected this protocol will be implemented in other Federal hospital facilities.

ii Other FDA program activities to provide quality assurance guidance to diagnostic x-ray facilities are also under way. A seminar series has been sponsored to collect information on active quality assurance programs. A Quality Assurance Catalog is being developed as a reference guide to available equipment, techniques, and training in the area. Quality assurance manuals are being written to provide detailed guidance on particular components of the x-ray system.

b. Development of programs enabling the State radiation control agencies to assist facilities in dealing with specific quality assurance problems. Three program actions have been launched in the area.

i The Dental Exposure Normalization Technique (DENT) program was the initial FDA quality assurance program effort. DENT was developed by FDA for use by State and local radiation control agencies in encouraging dentists to standardize dental x-ray machine exposures within established ranges that produce high quality x-ray films with acceptable patient exposures. It is primarily an educational effort amined at the dental radiology personnel rather than a survey to check for compliance of the x-ray machine with Federal and State regulations.

During 1975, full-scale DENT programs were under way in 16 States, local subdivisions, and Federal agencies. These programs are expected to reach 30,600 dental x-ray machines. In addition, pilot DENT programs in five more States were expected to reach 1700 machines. In the following year it is projected that eight additional States will initiate programs reaching 17,000 more machines. These efforts represent a substantial expansion of pre-1975 efforts which tested 2360 machines in six States. Exposure reductions per dental bitewing radiograph of over 30 percent have been achieved in States which have completed the first round of the program.

ii The FDA, in cooperation with the radiation control agencies of the District of Columbia and of Pennsylvania, is developing a mammography quality assurance program. This is an educational program aimed at facilities doing mammography and designed to minimize patient exposure from x-rays of the breast while improving image quality. The methodology is based on that of the successful DENT program. Groundwork for the program involves identifying the facilities doing mammography and the number of units at each facility. The local medical and radiological societies have given valuable cooperation in this program. In later stages, thermoluminescent dosimetry cards are used to identify facilities which appear to be giving unnecessarily high exposures. These facilities are visited by State radiation control personnel who advise the facility personnel on what quality assurance actions should be implemented to reduce the exposure. It is expected that the pilot test of this program will screen mammography radiation exposures in 22 facilities in the District of Columbia and in 250 to 400 facilities in Pennsylvania.

iii During 1975, the Food and Drug Administration, in cooperation with the American College of Radiology and the West Virginia State Department of Health, field tested a diagnostic radiology quality assurance program for future implementation by State radiation control personnel. The first phase involved visits to a broad spectrum of x-ray facilities, ranging from doctors' offices to a large hospital, by combined teams of Federal and State personnel. The purposes of this phase were to test quality assurance instruments and procedures in clinical facilities, to assist facilities through identifying equipment maintenance and use problems, and to determine the practicality of a State radiation health program performing a quality assurance consultation service for radiological facilities in addition to their traditional regulatory duties. At each site, numerous measurements were made of the physical parameters associated with the x-ray system. Each facility was given a report on the survey results and any potential problems detected. During the second phase, efforts are being made to correlate the results of physical measurements with evaluations by radiologists of the quality of films supplied by the facility. The goal is to identify equipment problems requiring special attention. In addition, the survey forms and procedures are being revised in preparation for expanded use in other States.

FDA Educational Programs

In addition to establishing guidelines for good practices in medical radiology, the Bureau of Radiological Health, FDA, develops and implements educational programs in radiation protection for both health professionals and consumers, as specified in Section 356 of the Public Health Service Act, as amended by PL 90–602. The present status of a few of these programs are summarized below.

Radiological Health Sciences Learning Laboratory

More than 300,000 physicians currently practice in the United States. Most of them either use diagnostic radiology themselves or rely heavily on its benefits. They are directly responsible for ordering the examination of the patient, overseeing the conduct of the examination, interpreting the results, and applying this interpretation to the health care of the patient. Through an FDA contract, the University of California at San Francisco has developed a comprehensive educational system which teaches all these elements of x-ray usage, and emphasizes the radiation protection aspects, to medical students, residents and practising physicians of x-ray using specialties. This system, called the Radiological Health Sciences Learning Laboratory, is directed at the three phases of the radiologic examination: selection of the patient; conduct of the examination; and interpretation of the results. All medical students, as future selectors of patients for radiographic examinations, should be trained in the elements of patient selection; these are presented in a series of lectures in the Learning Laboratory. Students who will be radiology residents, and other future physicians who plan to supervise the use of radiographic equipment, should be acquainted with technical aspects of the actual performance of radiological examinations. This material is covered in a series of lectures and laboratory experiments designed to be used with a special training x-ray machine and mannequins. All physicians who will be involved in interpretation of radiographic examinations and the use of this information in patient diagnosis and treatment need training in the interpretation of radiographs. The learning file, which is a major part of the Learning Laboratory, provides simulated clinical experience with 1200 documented radiographic cases in self-teaching format, reproduced on full size x-ray film. The system is now being made available at cost to medical schools through the American College of Radiology under agreement with FDA; thus far, more than 30 institutions have purchased it, and orders have been placed for over 40 more. It is anticipated that within 3 to 5 years, essentially all medical schools and radiology residency programs will be utilizing the Learning Laboratory system.

Dental Training Packages

The radiation exposure to patients from dental x-ray examinations could be drastically reduced by adherence to such straightforward radiation protection principles as the use of fast films, proper beam-limiting cones, and standardized darkroom procedures. The FDA is currently conducting several training efforts directed at teaching these principles to dental auxiliaries, dental students, dentists, and individuals involved in the education of dentists and dental auxiliaries.

An instructional program has been developed which presents an 8-hour curriculum for dental auxiliaries in the safe operation of x-ray equipment, protection of the patient, beam limitation, and other radiation protection principles. The package includes "home-study" material which the auxiliary can study on his own time without the aid of a professional. The package was originally developed for the Maryland State Dental Association and is currently being used on a review basis. Subject to this review and completion of necessary revision, the package will be made available for sale and distribution on a nationwide basis. In addition, the FDA plans to publish the "home-study" material as a separate document.

The importance of dental darkroom practices in reducing unnecessary radiation exposure in dentistry has long been recognized. Through the development, distribution, and sale of a Slide-Tape Lecture Series on Dental Darkroom Procedures, the FDA is actively working to improve darkroom practices. This program is a multi-media, self-contained series of three 20-minute slide/tape presentations on dental darkroom requirements, processing procedures, and film processing failures with related corrective measures. This package provides dental educators with material which can be used in schools for dental auxiliaries, in dental schools, and in continuing education programs for licensed practitioners.

Radiologic Technologist Training Packages

The FDA produces a series of multi-media packaged training programs for radiologic technologists. The series is entitled: *Radiation Protection During Medical X-Ray Examinations* and is distributed through the National Audiovisual Center of the General Services Administration. The program is designed in modular form to allow continual addition of parts as new information becomes available and as new FDA programs are developed. Approximately one-half of the 1200 radiologic technology education programs have already purchased one or more parts of the series. The material is also available on a loan basis from regional and State radiological health offices.

Systematized Continuing Education

In 1975, the FDA pilot tested, through contract with the American Society of Radiologic Technologists, a self-assessment program of continuing education for practicing diagnostic radiologic technologists. The program consists of approximately 300 questions covering 10 basic subject matter categories. It also includes identification of available educational materials related to each of the categories. Plans are being formulated to make the material available to diagnostic x-ray equipment operators on a nationwide basis and to design the program for continued updating and expansion.

Radiation Protection Syllabus

In 1975, the FDA, in cooperation with the American Society of Radiologic Technologists, developed a radiation protection syllabus based on behavioral objectives. This syllabus will be included in a new major revision of the *Curriculum and Teacher's Syllabus for Schools of Radiologic Technology* to be completed by ASRT in 1976. This document is the basic educational guide for all radiologic technology schools approved by the American Medical Association Council on Medical Education.

Training Seminars

In order to upgrade the competence of State and local radiation control personnel to carry out their radiation protection responsibilities, FDA's Bureau of Radiological Health helps States and regions conduct seminars and workshops in various aspects of radiological health. Some of the seminars are aimed at teaching new personnel the basic principles of radiation science and protection; others concentrate on the skills and techniques necessary for surveying and evaluating medical x-ray equipment in hospitals and offices; still others deal with the inspection of consumer products such as microwave ovens.

This program has been active for over a decade, and has been largely responsible for establishing and maintaining the pool of manpower trained in radiation protection among the State and local radiation control agencies. However, because of increased emphasis in recent years on educating users of medical radiation, as well as staff and budget restrictions, the number of these seminars presented by FDA has been sharply curtailed. Nonetheless, during 1975 approximately 300 individuals were trained through approximately 15 seminars. In the future, the emphasis of this training program will be placed on the production of audio-visual materials, primarily video tapes, for use in State sponsored training.

SURVEILLANCE ACTIVITIES

Several monitoring programs in the medical radiation area are conducted by the Bureau of Radiological Health, FDA. These serve to assess population exposure and trends in medical radiation usage, assist in measuring the effectiveness of Federal and State radiation control activities, and provide a basis for effective planning of radiation protection and quality assurance action programs. The status of several of these surveillance projects are described below.

Nationwide Evaluation of X-Ray Trends (NEXT)

The NEXT Task Force, a Federal-State partnership, was established by the Conference of State Radiation Control Program Directors and the Bureau of Radiological Health in 1971. Its charge is to design a system to provide States with a means for setting program priorities and measuring the impact of programs in reducing diagnostic x-ray exposure.

With both financial and technical support from the FDA, the Task Force has developed a system for measuring the effectiveness of State and Federal regulatory agency activities directed at reducing patient radiation exposure during diagnostic radiography. The resulting system, which is called the Organ Dose Index System, was successfully pilot-tested during the spring of 1972. The system is now being used by the three military services, U.S. Coast Guard, Bureau of Prisons, U.S. Public Health Service, Indian Health Service, and 38 States.

The system, designed to serve as an adjunct to the State or agency's x-ray installation inspection program, is based on measurements of patient exposure and x-ray dose to the reproductive organs received by a "standard patient" during the radiographic procedures most frequently performed at each x-ray facility. Data are collected using standardized survey procedures, forms, and test equipment developed by the Task Force.

The data outputs from the system permit users to compare mean values for reproductive organ dose, exposure at skin entrance, beam size, and other parameters for radiographic exams performed by practitioners in their State or agency with those for all other users of the system before and after the implementation of programs developed in response to PL 90–602.

During 1975, the NEXT Task Force has unanimously moved to increase the accuracy of NEXT data by adding more computer checks to evaluate the incorporation of questionable data with the system and by requiring the use of calibrated survey instruments.

According to Task Force plans, five additional checks will be included in the NEXT computer system as a means of improving data accuracy. The checks will verify that:

Exposure readings are no higher than the range of the survey instrument used to make the measurements,

The repeat exposure performed during a survey does not vary by more than 10 percent from the original exposure,

The three half-value layer exposure measurements recorded during the survey decrease as filtration is added,

The added filtration for half-value layer determinations was chosen according to NEXT survey instructions, and

The calculated half-value layer is within pre-established limits.

Regarding instrument calibration, the Task Force set September 1, 1975 as the target date after which only calibrated instruments would be used for NEXT surveys. In addition, the recommendation was adopted that instruments be calibrated annually by the BRH.

Front-End Analysis

The FDA has contracted to pilot test a survey methodology in Virginia, Maryland and the District of Columbia as a preliminary to a National study in Fy-77. The study will attempt to define the predominant influences (e.g., education, work environment, attitude, regulations, knowledge, etc.) on x-ray equipment operator practices. The information obtained through direct interview of equipment operators will be used by FDA and disseminated to other agencies and the radiology professions as a basis for more informed planning regarding radiation safety and quality assurance programs directed at the radiology community.

APPRAISAL OF INCIDENCE OF BIOLOGICAL INJURY AND EFFECTS

Manufacturers are required by 21 CFR 1002.20 to report accidental radiation occurrences to the Bureau of Radiological Health, FDA. All accidental occurrences from electronic products that are known to the manufacturer, and which arise from the manufacturing, testing, or use of any product introduced or intended to be introduced into commerce, must be reported. Six incidents were reported by manufacturers to the Bureau during calendar year 1975 as a result of the requirements of 21 CFR 1002.20 and were investigated to determine their causes. Nine incidents involving radiation exposure were reported to the Radiation Incidents Registry, BRH, from a variety of sources.

Approximately 209 claims of eye and skin injury to 232 persons, associated with the use of an ultraviolet dental device, were reported during 1975. A corrective action program was completed by the Bureau to ameliorate the problems associated with the ultraviolet device. Twelve incidents, involving high intensity mercury vapor lamps used for lighting purposes, reportedly resulted in eye and skin injuries to 50 persons. The industry is planning to adopt a voluntary standard for high-intensity mercury vapor lamps to control the problem, to be developed by the American National Standards Institute. The BRH is conducting a parallel approach to develop a regulatory standard if the voluntary approach is unsuccessful. See Table 4.3 for summary data on numbers of persons involved in various types of radiation exposure incidents.

Regulations issued under the Radiation Control for Health and Safety Act (21 CFR, Chapter I, Subchapter J) require that manufacturers of certain electronic products submit reports and keep records related to the electronic product radiation safety, including the applicable radiation testing and quality control programs that the manufacturers conduct. Initial reports and reports of model changes are required from manufacturers of certain classes of products. Manufacturers of microwave ovens, television receivers, cold-cathode tubes, medical x-ray units, baggage x-ray units, sunlamps, lasers, and certain other products are also required to establish and maintain records including quality control and testing records.

During 1975, 1,040 initial reports, model change reports, annual reports, and exemption requests were received. Also about 1,600 supplements to such reports and requests for exemption were submitted. Fifteen hundred reports and supplements thereto were reviewed and evaluated. Over 5,400 pieces of incoming correspondence (including reports and exemption requests) were received and acted upon.

Approximately 530 letters were sent to known or assumed manufacturers of electronic products advising them of their reporting obligations and requesting appropriate reports. Approximately 180 followup actions, in the form of letters or telephone calls, were taken with various manufacturers to obtain required reports, supplements, or other regulatory information and data.

TABLE 4.3
NUMBER OF INCIDENTS AND NUMBER OF PERSONS REPORTED EXPOSED TO VARIOUS TYPES OF RADIATION SOURCES RADIATION INCIDENTS REGISTRY, 1970–1975

Sources	Number of incidents	Number of persons	Number of incidents	Number of persons
Ionizing				
Industrial x-ray units	1	1	80	88
X-ray units in universities & laboratories	3	3	41	51
Medical & dental x-ray units	4	11	65	125
Gamma	-	-	6	14
Television	-	-	1	1
Nonionizing				
Ultraviolet	226	286	310	390
Microwave	1	1	51	53
Laser	2	2	21	23
High frequency radiowaves	-	-	1	1
Infrared	-	-	1	1
Ionizing and Nonionizing	-	-	5	5
Ultrasound	-	-	3	5
TOTAL	237	304	596	769

Additional Accomplishments

Test Stand for X-Ray Equipment Compliance Testing – A patent recently has been assigned for a test stand designed by BRH personnel for use in evaluating the performance characteristics of diagnostic x-ray systems. The device has several unique features that simplify the testing of x-ray equipment for compliance with the Federal performance standard. Although developed primarily for compliance testing, it also has been approved by the Task Force on the Nationwide Evaluation of X-Ray Trends (NEXT) for use in collecting survey data.

X-Ray Exposure and Time Monitor – A single portable instrument capable of measuring both radiation exposure and exposure time from a typical diagnostic x-ray machine is the first of its kind to become commercially available.

The FDA initially conceived the design of the instrument, and developed a feasibility model, as a means for making field measurements of timer accuracy and exposure to verify equipment compliance with the Federal performance standard for diagnostic x-ray systems. The FDA awarded a contract in 1974 to refine and package the instrument for production.

The new instrument uses an air-equivalent ionization chamber in conjunction with a charge digitizer and digital-processing unit to measure exposure, exposure rate, pulse exposure, and pulse width. Principal advantages of the instrument are: improved accuracy and reliability over existing devices used for making x-ray exposure measurements in the field; convenience, in that it replaces two instruments with one; and ease of use.

Long-Term Effects of Prenatal and Postnatal Ionizing Radiation Exposure in the Beagle (Collaborative Radiological Health Laboratory) – The Collaborative Radiological Health Laboratory project, under contract with FDA, is a study of the long-term effects of prenatal and early postnatal ionizing radiation exposure in the beagle. The effects in the beagle of a single exposure of low levels of radiation are being investigated in terms of long-term effects. This study will contribute significantly to the determination of the hazards associated with human prenatal and early postnatal exposure to ionizing radiation. The project has made approximately 100 original contributions to the published scientific literature.

Comparative Thyroid Tumor Induction in Rats from Iodine-131 and X-Irradiation – The objective of this study is to evaluate the risk and the relative radiosensitivity of thyroid carcinoma from internally administered Iodine-131 and x-irradiations in the dose range of 75 to 1,000 rads. Also, a possible radiogenic synergistic effect between the thyroid and the pituitary with x radiation will be investigated.

Findings in a recent epidemiologic study revealed that a significant number of thyroid carcinoma was incurred by patients treated with x-irradiation of the scalp for tinea capitis (ringworm of the scalp) at prepubertal ages. The predominant latent period was from 10 to 20 years, and the dose to the thyroid was estimated to be about 6.5 rads. Doses received by patients from I-131, currently used in nuclear medicine for thyroid function and diagnostic procedures, ranged from approximately ten to several hundred rads. Studies in the past, involving humans and animals, suggested that the thyroid gland is not very radiosensitive and that thyroid radiosensitivity to x-irradiation is approximately ten times greater than that from internally administered I-131. It should be noted that previous studies employed high radiation doses to the thyroid. As a result, the thyroid glands were partially ablated, which might account for the low incidence of observed latent thyroid tumor.

Evaluation of Dose from Uranium in Dental Porcelain – The FDA is studying the use of uranium in dental porcelain with respect to potential doses due to alpha and beta emissions. Preliminary results of the study were reported in November at the American Public Health Association Annual Conference.

Concern over the potential radiation hazard from uranium in artificial teeth arose from earlier studies in England and Switzerland which indicated the dose from such sources exceeded the maximum permissible dose for the general public recommended by the International Commission on Radiation Protection (ICRP). Although it is believed that the uranium concentrations being used by U.S. manufacturers are considerably lower that those found in the British and Swiss studies, very little data are presently available. The Bureau of Medical Devices and Diagnostic Products asked BRH to develop this information for use as a basis in evaluating the need for Federal guidelines on the concentration of uranium in dental porcelain.

The presence of uranium in artificial teeth is considered essential because no other substance has been found to yield as broad an imitation of the fluorescence found in natural teeth under all lighting conditions. The fluorescent effect is particularly noticeable when the lighting contains a substantial ultraviolet component. Porcelain without uranium often emits green, yellow, or no fluorescence. Since a large percentage of crowns and dentures are prescribed primarily for cosmetic reasons, manufacturers of dental prosthetics routinely incorporate uranium in their products.

Some 18 sets of artificial teeth and 23 powders submitted by domestic and foreign manufacturers are being analyzed by the BRH for alpha and beta emissions as well as for uranium concentration. Preliminary results indicate the annual dose from these materials may be higher than the ICRP recommended levels of 3.0 rems per year for the skin and 1.5 rems per year for other organs. However, it has not yet been determined whether a significant amount of this dose is delivered to the sensitive basal layer of the oral tissue.

Complete results of the study will be published in 1976 as a BRH report.

SCREENING OF ELECTRON MICROSCOPES FOR X-RAY LEAKAGE

In an effort to determine whether operators of electron microscopes are, in fact, subjected to unnecessary exposure, EPA, with the cooperation of the health physics staff on the campus of the National Institutes of Health and the Veterans Administration Hospital in Washington, D.C., surveyed 45 electron microscopes which operated in the energy range of 50 to 125 KeV.

Seven of the microscopes surveyed emitted continuously detectable radiation, and four emitted radiation only for short periods of time; no leakage was detected at the location of the operator or his co-workers. A recommendation for routine screening was made in the interest of personnel safety, even though there was no detectable leakage at the operator's location. The study also recommended that corrective action, such as installation of additional shielding, be taken if the screening survey indicates the presence of x-ray leakage that could result in unnecessary personnel exposure.

X-RAY MACHINE DONATIONS

Goodwill Industries of America, The Salvation Army, and The Volunteers of America have taken actions to prevent their organizations from accepting donations of used medical and dental x-ray equipment.

In letters to the three charitable organizations, the FDA urged that donations of used x-ray equipment be refused because sale of the units to uninformed purchasers could result in serious radiation injury. The new Federal standard for diagnostic x-ray machines is likely to reduce the resale value of used equipment and, as a result, it may be disposed of through donations. In response, the Commissioner of The Salvation Army stated: "We have tried in the past to refuse donations of medical or dental x-ray machines, unless they are secured specifically for our hospital mission overseas. In that case, we have them examined... before accepting or shipping them. So far as acceptance of such donations in our institutions in the United States, we will alert the necessary departments and ask their cooperation." In a similar vane, Commander in Chief of The Volunteers of America, reported that all program centers have been instructed that should such equipment be picked up inadvertently, "it is to be made inoperable immediately and disposed of."

GENERAL AMENDMENTS PROPOSED FOR DIAGNOSTIC X-RAY STANDARD

The Food and Drug Administration has proposed a group of 11 general amendments to the Federal performance standard for diagnostic x-ray systems and their major components. The notice of proposed rulemaking was published in the *Federal Register* on June 11, 1975.

The proposed amendments include revisions of the list of major components to which the standard applies; addition of alternate certification and labeling procedures for products marketed as a combination of two or more major components; strengthening of the requirements for fluoroscopic x-ray field limitation and high-level controls; and revision of the wording of several definitions, performance requirements, and methods for determining compliance.

Specifically, the proposed amendments would:

Revise the list of major components so the standard applies to spot-film devices and image intensifiers rather than fluoroscopic imaging assemblies. This revision would allow the list of components to correspond more closely to current manufacturing and marketing practices, and facilitate product certification and identification by the manufacturer and enforcement of the standard by the Bureau.

Add cephalometric devices to the list of major components regulated by the standard. These devices are used in dentistry for radiographic visualization of the patient's head. They were not addressed in the original standard and are being added because they must be selected and installed correctly for the x-ray system to meet the requirements regarding x-ray field limitation and alignment.

Revise the definition of "leakage technique factors" to state that the maximum rated peak tube potential is such a factor. This proposed revision is intended to clarify the definition and is consistent with previously issued interpretations.

Revise the definition of the "visible area" of an image receptor to assure correct interpretation of the requirements concerning alignment of the fluoroscopic x-ray field and image intensifier. Again, the proposed revision is intended solely for clarity and is consistent with previous interpretations.

Revise the definition of "x-ray control" by adding timers, phototimers, and automatic brightness stabilizers as examples. This revision will make it clear that these items are considered to be controls and must be certified separately if they are not integral parts of other components.

COMPLIANCE ACTIONS

General

The compliance and defect investigations of FDA consist of authorized inspections and reviews of record keeping, plant inspections authorized for cause, and plant inspections arranged with manufacturers on a voluntary basis. Compliance with applicable standards are determined by inhouse laboratory analyses of products, as well as reviews of reports and quality control data required of the manufacturer to be submitted to FDA.

A total of six Compliance Programs and four Program Circulars were issued in calendar year 1975. These Programs provide guidance for field and headquarters personnel in conducting compliance activities in the following areas: Field and Laboratory Testing of Microwave Ovens, Inspection of Microwave Oven Dealer/Distributor Records, Imported Electronic Products, Laboratory Testing of Television Receivers, Laboratory Testing of Cold-Cathode Gas Discharge Tubes, and Field Activities Involving Diagnostic and Cabinet X-Ray Equipment.

During 1975, there were 424 petitions approved for the importation of electronic products that were not in compliance with applicable Federal performance standards at the time they were offered for import. Of these, 299 were exemption requests for products imported for purposes of research, investigations, studies, demonstrations, or training. All these products have been or are to be exported or destroyed. The remaining 125 were applications to bring the electronic products into compliance with applicable Federal performance standards prior to introduction into commerce. These have been or will be brought into compliance or they will be exported or destroyed.

Eighty-two compliance actions, affecting more than 507,000 radiation-producing products, were in progress during the 1975 calendar year. Of these, 41 compliance actions were initiated during this time and involve 51,000 products.

These compliance actions involved television receivers, microwave ovens, medical x-ray units, dental x-ray units, cabinet x-ray units, including those used for inspection of carry-on baggage at airports, oscilloscopes, industrial x-ray machines, and ultraviolet dental appliances.

Twelve compliance actions in progress, 7 of which were initiated during the year, were the result of inadequate quality control programs or failure to submit a required report. It is prohibited for products concerned to be introduced into commerce until the program disapproval has been rescinded.

Television Receivers

There have been 164 television receivers laboratory tested in accordance with the Federal Performance Standard for Television Receivers. Compliance action cases were initiated with seven manufacturers of television receivers.

During February 1975, two manufacturers reported that several models of their television receivers were in noncompliance with the Federal standard and would be corrected. During the remainder of the year, two other manufacturers were found to have introduced noncompliant receivers into production. More than 17,000 receivers are involved in these four compliance actions and carry a potential radiation hazard of 2 to 4 times the maximum limits allowed by the Federal standard for radiation emission. The three other compliance actions taken involved television monitors, projectors, and oscilloscopes.

Medical and Dental X-Ray Equipment

There have been 14 major components of x-ray systems and 11 complete x-ray systems laboratory tested in accordance with the Federal Performance Standard for Diagnostic X-Ray Systems and their Major Components. Compliance action cases were initiated with 24 manufacturers of diagnostic x-ray equipment. Fifteen quality control and testing programs were disapproved pending further information or requiring a change in the program. Eleven of these disapprovals have been rescinded after receipt and review of additional submissions.

Cabinet and Airport X-Ray Units

Four quality control and testing programs were disapproved. One disaproval was rescinded after receipt and review of additional information. Compliance actions were taken against the remaining manufacturers.

MISCELLANEOUS ACTIONS

Quality Assurance – During 1975, the Food and Drug Administration, in cooperation with the American College of Radiology and the West Virginia State Department of Health, field tested a diagnostic radiology quality assurance program for future implementation by State radiation control personnel. The first phase involved visits to a broad spectrum of x-ray facilities, ranging from doctors' offices to a large hospital, by combined teams of Federal and State personnel. The purposes of this phase were to test quality assurance instruments and procedures in clinical facilities, to assist facilities through identifying equipment maintenance and use problems, and to determine the practicality of a State radiation health program performing a quality assurance consultation service for radiological facilities in addition to their traditional regulatory duties.

The Food and Drug Administration has initiated a program, in cooperation with the Public Health Service Hospital in Baltimore, to assess the results of a facility-based quality assurance program, carried out by hospital staff members, to assure consistent radiographic quality. The expected result of the program is to identify practical quality assurance procedures that could be recommended for x-ray facilities, including those of the Federal Government.

The FDA in cooperation with the radiation control agencies of the District of Columbia and of Pennsylvania is developing a mammography quality assurance program. This is an educational program aimed at facilities doing mammography and designed to minimize patient exposure from x-rays of the breast while improving image quality. The methodology is based on that of the successful DENT program. Groundwork for the program involves identifying the facilities doing mammography and the number of units at each facility. The local medical and radiological societies have given valuable cooperation in this program. It is expected that the pilot test of this program will screen mammography radiation exposures in 22 facilities in the District of Columbia and in 250 to 400 facilities in Pennsylvania.

DENT – DENT is a program developed by FDA for use by State and local radiation control agencies in encouraging dentists to standardize dental x-ray machine exposures within established ranges that produce high quality x-ray films with acceptable patient exposures. It is primarily an educational effort aimed at the dental radiology personnel rather than a survey to check for compliance of the x-ray machine with Federal and State regulations.

During 1975, full-scale DENT programs were under way in 16 States, local subdivisions, and Federal agencies. These programs are expected to reach 30,600 dental x-ray machines. In addition, pilot DENT programs in five more States were expected to reach 1700 machines. In the following year it is projected that eight additional States will initiate programs reaching 17,000 more machines. These efforts represent a substantial expansion of pre-1975 efforts which tested 2360 machines in six States.

ISSUES OF OCCUPATIONAL EXPOSURE

Current guidance on occupational exposure is contained in the former Federal Radiation Council's Memorandum for the President, "Radiation Protection Guidance for Federal Agencies," approved and signed by the President on May 13, 1960. These guides are used by Federal agencies in the preparation of standards and regulations for their respective areas of authority.

During the sixteen years since this guidance was established, there has been an increase in the number of persons occupationally exposed; changes have been made in methods of calculating doses and their effects; new national requirements have been promulgated on increasing uses of sources; new occupations have been created and have exposed sensitive population groups; and new and relevant scientific information on the risk of exposure to low-levels of radiation has been acquired.

Because of the increased number of persons being exposed to ionizing radiation and increased information on the risks of radiation exposure, the Environmental Protection Agency has undertaken a program to reconsider all factors relevant to updated Federal guides for occupational exposure. As part of the program, EPA established an Interagency Committee on Occupational Exposures to Ionizing Radiation in September 1974 to advise EPA in developing guides sufficient to protect the radiation worker from undue risk.

During the first half of 1975, the occupational exposure program's task groups investigated problems associated with the major issues of occupational exposures. Dose-to-risk conversion factors were calculated to facilitate evaluation of the effects of being exposed to radiation; a survey of government agency exposure records was performed to assess the current level of occupational exposures; and the risks associated with various radiation and non-radiation occupations were appraised and compared. The results of these tasks were presented at the Interagency Committee meeting in early August 1975.

Four major issues of occupational exposures identified by the Interagency Committee are as follows:

1. Determination of the Radiation Protection Guide (RPG)

EPA reported that selecting the RPG on the basis of a cost-benefit analysis was not feasible because there were too many uncertainties in assessing the costs and benefits of radiation protection in the nuclear industry. From the information that was available, EPA believes that comparative risk would be the most reasonable basis for establishing the RPG.

In the comparative risk approach, a method is devised to evaluate the risk associated with being exposed to radiation. This method is used to determine the risk that would result from proposed RPG levels which are then studied and compared with the risks involved in non-radiation occupations. A result of this analysis was that a radiation worker exposed at 5 rems/year faces a risk between those found in the average and high accidental death risk industries. The examination of radiation risks is continuing and is expected to be able to provide basic data for determining the RPG.

2. Misuse of the accumulated exposure rule of 5 (N-18)

Under current regulations (10 CFR 20) cumulative exposure of radiation workers is limited to a number of rems dependent on the age of the worker. The formula allows 5 (N-18) rems of cumulative exposure. It was pointed out by EPA that under current Federal guidance, a radiation worker could conceivably be exposed to 12 rems in a single year (3 rems/quarter) if a sufficient "exposure bank account" had accumulated using the 5 (N-18) rule.

3. Assurance that exposures are ALRA

The Committee restated the basic premise that since exposure to any level of radiation carries a risk of injury, all exposures should be kept as low as is reasonably achievable. It was further stated that the updated Federal guides should contain a mechanism to assure that exposures below the RPG will indeed be as low as reasonably achievable. An example was presented in which administrative surveillance and monitoring requirements were increased with increasing radiation exposure.

4. Provision for exceeding the RPG

The Committee acknowledged that the RPG could be exceeded in accident situations and that even some planned activities warrant exposure above the limit. The aid of the Committee was requested in developing suitable provisions for such exposures.

EPA also requested the Committee members to submit their personal opinions on these issues as well as formal comments on behalf of their respective agencies. Other areas to be addressed by the Occupational Exposures program include organ doses, extremity exposure guides and special groups (e.g., fertile women).

Progress in Radiation Protection

The details of the resolution of these issues will be contained in a technical document supporting the updated Federal guidance which will be available in 1976. Also contained in this document will be the results of a recently developed methodology which enhances comparative risk analyses that involve radiation related occupations. The model will be used to refine the evaluation of risk from various radiation levels and enable a more meaningful comparison with risks of occupations from non-radiation related industries.

In order to evaluate the impact of the updated Federal guidance and to acquire an accurate perspective of occupational exposure levels, EPA has under development a program to compile statistical data on annual occupational exposure to ionizing radiation within the United States. A contract that will investigate the feasible methods for assembling national occupational exposure data will be awarded early in 1976.

The Environmental Subcommittee of the Advisory Committee on Reactor Safety held a public meeting on August 7, 1975, on Occupational Radiation Exposure. Presentations in the general area of radiation protection were made by the NRC, ERDA, AIF, utilities, architect-engineer firms, nuclear reactor system vendors and labor unions. The transcript of the meeting is available and represents one of the most comprehensive reviews of radiation protection.

OCCUPATIONAL EXPOSURES – 1974

In past years the United States Atomic Energy Commission has published exposure data on both its licensees and contractor personnel. With the division, in January 1975, of the AEC into two agencies, the Nuclear Regulatory Commission and the Energy Research and Development Administration, each of the agencies assumed responsibility for collecting occupational radiation exposure information relating to its own activities.

In November 1975, the NRC issued the "Seventh Annual Occupational Radiation Exposure Report, 1975" (NUREG-75/108) and "Occupational Radiation Exposure of Light-Water Cooled Power Reactors. 1969–1974" NUREG-75/032, in June 1975. The bulk of the information contained therein was obtained from annual and termination reports submitted by certain types of NRC licensees (i.e., operating nuclear power reactors; industrial radiographers, fuel processors, fabricators, and reprocessors; commercial processors and distributors of specified quantities of byproduct material).

During 1974 some 421 licensees reported monitoring a total of approximately 85,000 individuals. Table 4.4 shows the distribution of the annual whole body exposures of these individuals for each of the covered categories of licensees. Of special interest are the exposures of "transient workers" (i.e., individuals who began and terminated two or more employments with different employers within the same calendar quarter). As can be seen from Table 4.5, the number of these workers has been increasing over the years; however, for the last three years the average individual quarterly exposure has been decreasing. Table 4.6 presents summary data of annual whole body exposures for covered licensees.

TABLE 4.4

Distribution of Annual Whole Body Exposures for Covered Licensees 1974

Covered Categories of NRC Licensees	Total No. Monitored	Exposure Ranges (Rems)																	
		Less Than Measurable	Less Than 0.10	0.10 0.25	0.25 0.50	0.50 0.75	0.75 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
Power Reactors	62,044	40,140	9,471	3,317	2,230	1,238	929	2,522	1,378	471	226	86	30	6	0	0	0	0	0
Industrial Radiography	8,792	3,849	1,740	939	635	424	323	547	209	74	22	17	5	2	3	0	1	2	0
Fuel Processing & Fabrication	10,921	6,304	1,801	959	772	316	146	275	126	83	60	23	12	16	12	16	0	0	0
Manufacturing & Distribution	3,340	1,513	748	504	144	84	69	125	59	46	17	21	7	1	2	0	0	0	0
TOTALS	85,097	51,806	13,760	5,719	3,781	2,062	1,467	3,469	1,772	674	325	147	54	25	17	16	1	2	0

TABLE 4.5

TRANSIENT WORKERS

1969 - 1974

	1969	1970	1971	1972	1973	1974	TOTALS
Number of Individuals Terminating Employment with Two or More Employers During One Calendar Quarter	8	28	14	66	154	313	583
Total Number of Man-Rems Accumulated	5.39	12.62	2.85	58.23	127.40	160.70	367.19
Average Individual Quarterly Exposure (Rem)	0.67	0.45	0.20	0.88	0.83	0.51	0.63

TABLE 4.6

SUMMARY OF ANNUAL WHOLE BODY EXPOSURES FOR COVERED LICENSEES
1968 - 1974

Year	Total No. Monitored	Percent of Exposures 2 Rems	No. of Annual Exposures 12 Rems
1968	36,836	97.2%	3
1969	31,176	96.5%	7
1970	36,164	96.1%	0
1971	36,311	95.3%	1
1972	44,690	95.7%	8
1973	67,862	95.0%	1
1974	85,097	96.4%	0

Exposures of Uranium Miners – 1974

The Mining Enforcement and Safety Administration of the Department of the Interior is responsible for the inspection and enforcement of its radiation protection regulations as they apply to workers in underground uranium mines. During 1974, for which data are available, radiation measurements were made in 70 underground uranium mines and 64 underground nonuranium mines and inspectors made 586 determinations of radon daughter concentrations. Average underground concentrations of radon daughters, as measured by inspectors, dropped by 22 percent in 1974 from the previous year. Only 0.6 percent of the uranium mine workers were reported to have received exposures of more that 4 Working Level Months (WLM) for the year. The highest exposure was 5.3 WLM. The average underground radon daughter concentrations, as measured by inspectors for 1975, are shown in Table 4.7. The distribution of individual radon daughter exposure, as reported by the mining companies in 1975, is shown in Table 4.8.

TABLE 4.7

1975 RADON DAUGHTER CONCENTRATIONS

(Federal Uranium Mine Inspections)

No. of Samples	Average	Maximum	No. and % of Samples Within Designated Range				
			0.0-0.3 WL	0.3-0.6 WL	0.6-1 WL	1-2 WL	>2 WL
1028	0.71 WL	25 WL	493	272	123	74	66
			48%	26.5%	12%	7.2%	6.4%

TABLE 4.8

1975 EMPLOYEE EXPOSURE

(as per Operator's Records)

No. of Employees	Average	Maximum	No. and % of Employees Exposed to Designated Range				
			0-1 WLM	1-2 WLM	2-3 WLM	3-4 WLM	>4 WLM
3344	1.07 WLM	5.15 WLM	1889	787	416	205	47
			56.5%	23.5%	12.4%	6.1%	1.4%

REFERENCES

1. *Population Exposure to X-Rays U.S. 1970*, DHEW Publication no. (FDA) 73–8047, November 1973.

2. Pre-release report: X-Ray Exposure Study (XES) Revised Estimates of 1964 and 1970 Genetically Significant Dose, BRH, February 1975.

3. K.Z. Morgan, Testimony before Senate Committee on Commerce on Public Law 90–602. March 8–12, 1973, Congress Rec. Serial No. 93–24 (1973), Pgs. 25–48.

NATURALLY-OCCURRING RADIOACTIVITY – CHAPTER 5

INTRODUCTION

Naturally-occurring radionuclides have always made a significant contribution to man's external radiation exposure, and they will continue to do so in the future. In many areas of the United States, the magnitude of terrestrial radiation exposure is relatively uniform. However, significant variations from the average exist in some regions due to high concentrations of uranium, thorium, and their decay products in soil.

The existence of natural radiation sources is not the result of man's activities. Exposure to external natural radiation occurs through cosmic radiation and radioactive elements originating in the earth's crust. An additional increment of external exposure, which accounts for a small percent of the total, is due to the presence of the radioactive decay products of radon and thoron in the atmosphere. Internal exposure to natural radiation sources is due to inhalation and ingestion of foods, liquids, and air containing naturally-occurring radionuclides. The intensity of natural radiation sources can be enhanced by some technological activity by man that is not expressly designed to produce radiation (1). That is, exposure from natural radioactivity can be increased and concentrated by man's industrial and other activities. Examples of this type of natural radiation sources are uranium mill tailings, radioactivity in construction materials, uranium in fertilizers, and cosmic radiation exposure due to air travel (1). Consequently man increases his exposure from these sources of natural radiation by means of his technology and his lifestyle.

As man seeks to improve his standard of living and demands greater use of available natural mineral resources, the earth's protective crust is broken and the naturally-occurring radioactive ores are processed increasing potential exposure to the population. Many industries mine and process raw materials which are found in strata containing significant concentrations of uranium, thorium, and their daughter products. This includes well established industries such as the phosphate, rare earth, and several other mining industries, as well as newer, less developed industries such as shale oil recovery and geothermal power production.

When the naturally-occurring radioactive materials are confined deep in the earth, they have little impact on man or the environment due to the shielding effect of the ground cover. However, when ore is mined, separated, processed into commercial products, and distributed, individuals and large populations can be subjected to exposure from the radioactive components.

These radioactive materials can affect man and the environment in four basic ways. First, gaseous and particulate radioactive materials are released to the air, becoming available for possible human inhalation and lowering the overall air quality. Second, the radioactive materials in the ores or the associated by-products can enter ground and surface waters by effluent discharges, land runoff, and leaching from waste piles. A third effect is caused by the close contact of workers with the radioactive material. The fourth potential impact is contamination of the food chain, which may result in man's ingestion of radioactive materials.

Substantial environmental and public health problems associated with natural radioactivity are emerging which require for their solutions effective regulatory roles in Federal agencies and in the States. The major problem areas have been identified for successfully addressing the issues. Many of these areas are the subject of extensive Environmental Protection Agency activity. Other areas will require intense involvement in the near future. In general, these areas call for

environmental assessment and the development of adequate control measures to minimize any public health risk from naturally-occurring radioactivity.

URANIUM MINE AND MILL TAILINGS

Active Uranium Mills

Large scale milling of uranium ore began in the United States in the late 1940's. The average time of operation of a uranium mill has been 12 to 15 years. As of December 1975, fifteen mills were operating in the United States (Table 5.1) with nominal capacities ranging from 150 to 7,000 tons of ore per day. These mills are characteristically located in arid, isolated regions of the west. Areas with significant high grade ore reserves are: Wyoming, 55 million tons; New Mexico, 50 million tons; Texas, 11 million tons; Colorado-Utah, 6 million tons; all other areas combined, 7 million tons. In recent years, there has been a sharp increase in the use of light-water-cooled nuclear reactors to generate electricity. There has been a parallel growth in the uranium fuel industry that provides the enriched uranium fuel for these operations (2).

A uranium mill extracts uranium from ore. The product is a semi-refined uranium compound called "yellowcake" which is the feed material for the production of uranium hexafluoride. Eighty percent of yellowcake is currently produced by a process that uses sulfuric acid to leach the uranium out of the ore; the remainder is produced by a sodium carbonate, alkali leach process.

The radioactivity in uranium ores depends primarily on the amount of uranium in the ore. The principal decay chain in the radioactive decay process for uranium ore is that beginning with uranium-238 and ending with lead-206. Most of the ores currently being mined are 0.1 percent or more uranium oxide. Generally, the ores are stockpiled near the mills and blended to provide a uniform feed of approximately 0.2 percent uranium oxide. During milling, 20 to 80 percent of the radon gas in the ore and small fractions of the other radionuclides are released to the environment(3). Almost all of the radioactive decay products of the uranium ore end up in the tailings, mostly in the tailings solids, but with small percentages in solution. Large amounts of solid waste tailings remain following the removal of the uranium from the ore. A typical mill may generate 1,800 metric tons per day of tailings solids slurried in 2,500 metric tons of waste milling solutions. Over the lifetime of the mill, 100 to 200 acres may permanently be committed to store this material. Included in the tailings are 97 percent of the radioactive decay products of the uranium and about 4 percent of the original uranium.

These "tailings piles" will have a radiological impact on the environment through the air pathway by continuous discharge of radon-222 gas (a daughter of radium-226), through gamma rays given off by radium-226, radon-222 and daughters as they undergo radioactive decay, and finally through air and water pathways if radium-226 and thorium-230 are blown off the pile by wind or are leached from the pile due to water erosion.

New mills in the Rocky Mountains area are using impoundment technology in an attempt to approach zero liquid discharge levels. Utilizing a clay-core retention dam, two methods for seepage collection and return are being considered. When an impermeable geological formation underlies the retention system, seepage can be collected in a catch basin located at the foot of the dam and then pumped back into the retention pond. Wells may also be drilled downstream of the retention system into the subsurface formation where seepage can be collected and pumped back into the retention system. Impoundment of solids is being accomplished in older mills merely by construction of a dike with natural materials and filling the diked area with slurried tailings. The diking procedure, which is less costly initially, creates an above-ground pile of tailings which is difficult and costly to stabilize. While the mill is operating, this type of pile is also subject to wind and water erosion; therefore, new mills are not likely to be built using this type of solid waste control.

TABLE 5.1 STATUS OF ACTIVE URANIUM MILL SITES IN THE UNITED STATES AS OF DECEMBER 1975

State	Location	Name and/or Owner	Year Mill Started	Nominal Mill Capacity (Tons Ore per Day)	Tons of Tailings (In thousands)	Size of Tailings Pile (Acres)
*Colorado	Canon City	Cotter Corporation	1958	150-450	1,100	35
	Uravan	Union Carbide Corp.	1950	0-1300(a)	7,000	80
*New Mexico	Ambrosia Lake	Kerr-McGee Nuclear	1958	3600-7000	25,400(e)	200
	Blue Water	Anaconda Company	1953	3000	15,300(e)	250
	Grants	United Nuclear-Homestake Partners	1958	1650-3500	18,700(b)(e)	150
South Dakota	Edgemont	TVA (Mine-Development, Inc.)(c)	1956	250- 500	2,000	82
*Texas	Falls City	Conoco & Pioneer Nuclear, Inc.	1971	220-1750	2,600	200
	Ray Point(c)	Exxon, U.S.A. (Susquehanna-Western)	1970	200- 800	490	50
Utah	La Sal	Rio Algom Corporation	1972	500	739	45
	Moab	Atlas Corporation	1956	800-1500	7,800	120
*Washington	Ford	Dawn Mining Company	1957	0- 400	1,900	100
Wyoming	Gas Hills	Federal American Partners	1959	500- 950	4,000	100
	Gas Hills	Utah International, Inc.	1956	750-1200	5,500(e)	135
	Gas Hills	Union Carbide Corporation	1960	1000	4,000	61
	Jeffrey City	Western Nuclear, Inc.	1957	400-1200	3,000	60
	Powder River Basin	Highland Mill, Exxon, U.S.A.	1972	2000	2,200	250
	Riverton(c)	Susquehanna-Western	1958	500	900	40
	Shirley Basin	Petrotomics Company(d)	1962	525-1500	4,500(e)	50
	Shirley Basin	Utah International, Inc.	1971	1200	1,800(e)	250

(a) Ore processed at the Vanadium facility for the Manhattan project in 1943.

(b) Includes 1,200,000 tons from salvaged Homestake-New Mexico Partners Mill that was located on the present active site.

(c) Although the site license is still active, there is no present milling activity.

(d) Mill will reopen January 1, 1978 and handle about 1,600 tons per day.

(e) Estimated.

* Agreement States which have responsibility for licensing the mills. All others are licensed by NRC.

Uranium mill tailings piles are long half-life, low-level radioactive wastes. As such, they will require perpetual care. This will include occasional inspection and maintenance to insure integrity of the stabilizing cover, fencing, and of the warning signs around the pile. The maintenance associated with perpetual care of a stabilized dike system would probably be higher than that for the depression fill system, since there is a tendancy toward collapse of side slopes and possible inadequate drainage of precipitation from the pile.

In the milling operation, hazardous airborne gaseous and particulate wastes are generated from a number of different sources. These are mainly gaseous and particulate effluents from the ore crushing area, the fine ore bins, and the yellowcake packaging and drying area. Current practice involves the use of wet dust control systems for the ore crushing area and fine ore storage bins and wet scrubbers with bag filters for the yellowcake packaging and drying areas. The scrubber efficiency for the ore crushing area is about 95 percent, and for the yellowcake packaging and drying areas it is 99 percent (3).

Other sources of gas and dust which can be controlled are the open pit mine haul roads and the ore storage and blending pits. In some instances, the liquid content of the ore as mined may be sufficiently high to eliminate most dust formation in the ore storage and blending area; based on the information available, this problem appears potentially significant and it may be controlled in principle through sprinkling and by use of wind breaks. Dust generation on ore haul roads can also be controlled by sprinkling.

NRC Activities in Uranium Milling

In May 1975, the General Accounting Office (GAO) recommended that the Chairman of the NRC "(1) assess the capability and willingness of public health authorities or other State agencies to assume responsibility for and to adequately carry out programs for the long-term monitoring of tailings piles and for correcting any problems in tailings' stabilization and control programs, and (2) determine whether additional Federal authority is needed to improve such programs."

In August, NRC reported to the Committees on Government Operations of the U.S. House of Representatives and the Senate the actions taken and planned to implement the GAO recommendations.

NRC has direct regulatory jurisdiction over uranium mills in the States of Utah, Wyoming and South Dakota, currently numbering 10 active facilities. Under the "Agreement State" program whereby qualified States assume part of NRC's regulatory authority, eight other active mills are regulated, including the control of tailings, by the States of Colorado, New Mexico, Texas and Washington.

For a mill licensed by the NRC, an environmental monitoring program must be carried out, and the licensee must establish a program to prevent releases of tailings material and to restrict use of the area. NRC will also require a guarantee such as a surety bond to assure that the commitments will be fulfilled, and is discussing arrangements for the affected States to hold such surety bonds posted by the licensee.

In 1975, NRC received a petition requesting action to (a) prepare a generic environmental statement on uranium mill tailings, (b) cease all licensing actions connected with generating tailings until results of the environmental review are available, and (c) require mill owners to post performance bonds to assure that tailings will be stabilized prior to abandonment. The petition was published ofr comment and NRC will review these comments and take appropriate action in 1976.

ENVIRONMENTAL ANALYSIS OF THE URANIUM FUEL CYCLE

An environmental analysis related to uranium milling was included in supplementary information prepared by EPA for the hearings on the proposed standard (40 CFR 190) for the uranium fuel cycle (2,3).

Ambrosia Lake Study

In November 1975, a study was conducted by EPA to determine the ambient radiological air quality in the Ambrosia Lake area of New Mexico, a region of active uranium ore mining and milling operations. Three operating mills, one inactive mill, associated tailings ponds, and approximately 20 active mines contribute radon and radon progeny as well as airborne particulate material to the ambient air quality. During episodes of limited atmospheric dispersion, radon levels build up in the basin. Airborne particulate levels will give information on the radiological hazard associated with windblown tailings from active tailings ponds. The study should provide data on outdoor radon levels, indoor radon progeny concentrations and outdoor particulate concentrations for active mines and mills. A report on this study will be published by EPA in 1976.

Grants Mineral Belt Study

The first extensive study to determine the impact of the uranium mining and milling industry on ground water quality was completed by EPA in August 1975 in the Grants Mineral Belt area of New Mexico. The study had these objectives: 1) to assess the impact of waste discharges on ground water, 2) to evaluate the adequacy of company water quality monitoring networks, self-monitoring data, analytical procedures, and reporting requirements, and 3) to develop priorities for subsequent monitoring and other followup studies. Study findings revealed that excessive seepage of effluents from tailings ponds, unlined channels and, in one case, an injection well, resulted in elevated levels of radioactivity in natural ground water bodies. No adverse impacts on municipal water supplies were evident although three industrial potable supplies exceeded levels for radium in drinking water (4).

INACTIVE URANIUM MILL TAILINGS SITES

During the past 27 years there have been about 40 uranium ore processing mills that have produced uranium for sale to the Government and private industry. Twenty-four of these mills in eight western States have shut down leaving the accumulated radioactive residues or tailings. Two of these sites are currently under active NRC licenses and one site is maintained by the Federal Government. The remaining twenty-one inactive mills have tailings totaling 25 million tons with individual piles varying from 90,000 tons to 3 million tons (Table 5.2) (5).

Following hearings conducted in Washington, D.C., on March 12, 1974, by the Subcommittee on Raw Materials of the Joint Committee on Atomic Energy (JCAE), the Environmental Protection Agency and the Atomic Energy Commission (now the Energy Research and Development Administration) agreed to conduct a joint comprehensive study of inactive uranium mill tailings piles in the Western United States. The study, a two-phase undertaking, would be conducted by ERDA and EPA and the concerned States. During the period April-October 1974, EPA, ERDA, and State representatives conducted a Phase I study of the 21 inactive pile sites to define the extent of the problem and to recommend possible solutions. The Phase I findings

TABLE 5.2

MILL SITES INCLUDED IN PHASE I STUDY

	Years Operated	Tons of Tailings
Arizona		
Monument	1955 - 1967	1,200,000
Tuba City	1956 - 1966	800,000
Colorado		
Durango	1943 - 1963	1,555,000
Grand Junction	1951 - 1970	1,900,000
Gunnison	1958 - 1962	540,000
Maybell	1957 - 1964	2,600,000
Naturita	1939 - 1963	704,000
New Rifle	1958 - 1972	2,700,000
Old Rifle	1924 - 1958	350,000
Slick Rock (NC)	1931 - 1943	37,000
Slick Rock (UCC)	1957 - 1961	350,000
Idaho		
Lowman	1955 - 1960	90,000
New Mexico		
Ambrosia Lak	1958 - 1963	2,600,000
Shiprock	1954 - 1968	1,500,000
Oregon		
Lakeview	1958 - 1960	130,000
Texas		
Falls City	1961 - 1973	2,500,000
Ray Point	1970 - 1973	490,000
Utah		
Green River	1958 - 1961	123,000
Mexican Hat	1957 - 1965	2,200,000
Salt Lake City	1951 - 1968	1,700,000
Wyoming		
Converse County	1962 - 1965	187,000
Totals		25,256,000

formed the basis for the initiation of Phase II for 21 mill sites plus Riverton, Wyoming (NRC licensed facility), which would include evaluation of the problems and examination of alternative solutions, the preparation of cost estimates and detailed plans and specifications for alternative remedial action measures. Funds from the EPA energy fund were transferred to ERDA, which in turn entered into a contract with an architect-engineering company to begin Phase II. ERDA, the lead agency in these program efforts, has received additional funds from Congress to continue the study. Any remedial action that may result from the study will require legislation and additional funds.

Phase II Study at Salt Lake City

As a result of a previous study in 1974, EPA recommended remedial action on the tailings piles at the inactive *vitro* uranium mill site in Salt Lake City, Utah (6). During 1975, the Phase II engineering study at this site was initiated. A final report is being prepared by the architect-engineer contractor to ERDA to present costs of alternative remedial actions and will be sent to the JCAE and the State of Utah for their consideration as to which action should be taken.

Gamma Radiation Surveys

Gamma surveys to determine the extent of tailings spread by wind and water erosion were conducted by EPA for the Phase II program at 20 inactive mill sites in 1974 and the results of these surveys have been published. (7).

Potential Radiological Impact

As part of a program to determine which measures to use to control radioactivity from tailings piles at inactive uranium mill sites, EPA has prepared estimates of the potential radiological impact from the inactive uranium mill tailings piles. The gamma radiation field and the radon-222 release rates from inactive uranium mill tailings sites were estimated on the basis of the radium-226 concentration in a "typical" pile. Potential exposures to airborne particulate uranium, thorium-230, and radium-226 are estimated from field measurements. Although there are uncertainties in these estimates, the indicated conclusions are that the radon releases, which are difficult to control, are the hazard of greatest significance, that the radioactive particulate releases may sometimes be significant also, that ground and surface water supplies may become contaminated and thorough measurements are needed for assessment of individual piles (8).

Radon Exhalation

As a followup to the theoretical analysis of radon releases from inactive tailings piles, a program has been initiated to develop a model to determine radon-222 source terms in order to present a predictive capability for ambient air concentrations in a five-mile radius of tailings piles. Parameters, such as radium-226 concentration profiles, bulk density, porosity and moisture content will be studied. A description and verification of the measurement method for radon exhalation has been reported by EPA (9).

Navajo Nation Studies

Since 1968 the Federal Government has provided technical assistance and advice to the Navajo Nation on matters dealing with mill tailings piles on the Navajo reservation. In January 1975 a project was begun to decontaminate the Shiprock, New Mexico, inactive uranium mill site and its local environs. EPA has provided technical assistance in this effort to prevent immediate redistribution of the uranium mill tailings in the environment.

EPA assisted in a survey in 1975 of residences and structures in the Cane Valley area of Monument Valley, Arizona, to identify those structures using uranium mill tailings and ore in their construction and to assess the resulting radiation exposures. A review of the data indicated that no remedial action need be initiated at this time. More data on this potential problem will be collected when the Phase II study by ERDA is conducted in 1976.

Another EPA monitoring survey was completed at Mexican Hat, Utah, where former mill structures were being used for a heavy equipment operator's school. A review of present and past data indicated that the site should not be used as a living or working area because of radioactive contamination. An interim remedial action program was suggested by EPA until the Phase II program by ERDA is completed.

TRACK-ETCH BADGE DOSIMETRY STUDIES

Studies of natural radioactivity in the environment have created a requirement for an economical, convenient, noise free, and accurate method of determining radon daughter exposure levels in structures. In order to provide such a dosimetric method, EPA funded a contract to develop the measurement technique using the Track Etch principle. As part of a cooperative project with the State of Colorado, the Track Etch Badge was field tested at selected locations in Grand Junction, Colorado. Results of the Tract Etch Badges are being compared with results of the thermoluminescent dosimeter (TLD) air samplers operated at the same locations because TLD's currently represent the standard measuring technique.

The study has been completed and a draft of the final report was submitted to EPA by the contractor in late 1975. EPA plans to prepare a summary after receipt of the final report from the contractor.

NON-NUCLEAR ENERGY SOURCES

Geothermal

A potential source of energy for production of electricity, space heating, or industrial steam supplies is geothermal energy. Such energy, stored in reservoirs of hot water or steam in the earth's crust, is not expected to be a significant contributor to our overall energy needs. In fact, a recent EPA contract indicates that less than one percent of U.S. energy demand can be satisfied by geothermal sources (12). Furthermore, these will be highly localized uses in areas of geothermal activity, mostly in the southwest. Radioactivity as a potential environmental pollutant from geothermal sources is a secondary impact, primary impacts being from hydrogen sulfide, ammonia and methane in air, dissolved solids in water, and solid waste.

The Office of Radiation Programs Las Vegas Facility (ORP-LVF) of EPA conducted a sampling and analysis program for radioactivity in geothermal fluids in 1975. Nearly 140 hot springs and wells were sampled in the States of Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon and Utah. Analyses were performed for radon, radium, uranium, and thorium at EPA's Environmental Monitoring and Support Laboratory (EMSL) in Las Vegas and the Mound Laboratory (operated by Monsanto Research Corporation for the U.S. Energy Research and Development Administration (ERDA)) in Miamisburg, Ohio.

The purpose of this program is to characterize the radiochemical species in representative geothermal water sources, in order to determine the radiological impacts of anticipated activities with these sources. Such anticipated activities include use of geothermal sources for energy production via an electrical generating plant or by direct use of geothermal fluids or steam for residential space heating or industrial heat sources. While such activities with geothermal reservoirs do not specifically create additional radioactivity, as in a nuclear power plant, natural radioactivity in the form of members of the uranium and thorium natural decay series may be redistributed to the biosphere during utilization of geothermal fluids. In order to determine potential radiological consequences, the source activities must be known. A review of the literature regarding this subject yields little, if any, analytical results that would aid such a charcterization. Therefore, EPA initiated a program in 1974 to sample and analyze a number of these sources across a wide geographic area. The sampling and sample analyses have been completed; however, statistical correlation of the radioactivity to other factors, such as gross chemical, geographic or geologic parameters, has not been accomplished. It is hoped that the results of this program will provide the bases for future radiological impact studies connected with proposed practical utilizations of the energy available from these geothermal resources.

Preliminary results of the analyses of samples are reported in EPA Technical Note ORP/LV-75-8A, "Radioactivity Associated with Geothermal Waters in the Western United States." This report describes sample locations, sampling techniques, and the results of laboratory analyses. Data indicate Rn concentrations as high as 14,000 pCi/l and Ra concentration up to 1,500 pCi/l.

Coal

The radioactivity of coal used for power generation has received continued attention from research and regulatory groups. This interest is a result of recent coal-use trends which show an increasing dependence of electric utilities on low-sulfur western coals, some of which tend to have higher uranium concentrations than other coals. The radionuclide of concern in the burning of coal is radium-226. The concentration of radium in coal varies with the ash content and other factors, generally averaging approximately 1 pCi/g, although specific beds may contain much higher concentration (13). Generally, coal contains higher uranium concentration in the bituminous and lignite deposits than in anthracite. A coal-fired power plant can discharge amounts of such long-lived biologically significant radionuclides comparable in amount to those released from nuclear plants of similar size (14). In a well-run plant, a small fraction of the total radioactivity contained in the coal is released into the atmosphere in the form of fly ash. The remaining ash is handled in a variety of ways, some of which may involve opportunities for public exposures (15).

The United States Geological Survey has made extensive surveys of the trace composition of coals, lignites and other carbonaceous materials throughout the midwestern and western parts of the country. These surveys have found uranium concentrations ranging as high as 0.1 percent in some mineralized lignite beds of North and South Dakota (16). For unmineralized deposits, concentrations were similar to those found in other coal types.

Using source term data from such surveys, the Energy Research and Development Administration through its Oak Ridge Laboratory is presently performing computer modeling of potential population dose (at the fence-line) from coal-burning power plants. In this analysis, discharge and deposition data from the Allen Steam Plant study (17) are being used in the calculations.

The Environmental Protection Agency (EPA) has recognized the importance of assessing the radiological impact of the use of uraniferous coals on the environment and public health. As a first step in developing a program in this area, EPA has compiled a bibliography and literature survey for the assessment of the radiological impact of fossil fuel use. This literature survey is divided into three subject categories: radioactivity in coal, radioactivity in oil, and radioactivity in natural gas. Using this survey as a measure of current information on the subject, EPA through its Las Vegas Laboratory is planning to expand the current project to encompass field surveys and laboratory testing of various coal types, particularly western coals. The radiation exposure contribution due to the discharge of Rn-222 and Po-210 will receive special attention, through the use of computer modeling.

Natural Gas

Radon-222 permeates porous geological formations and is collected along with methane in production wells for natural gas. An earlier assessment of potential health effects from radon in natural gas (18) indicated that much of this radon is separated along with heavy hydrocarbons during routine processing. These heavy hydrocarbons are bottled under pressure for sale as liquefied petroleum gas (LPG). Therefore, further assessment was made of the potential health effects resulting from radon in LPG which is used in home appliances (19). This study indicated that the aggregate dose to the U.S. population would result in less than one health effect (lung cancer) a year. However, individual exposures could result in doses to the tracheobronchial epithelium of more than 200 mrem/y. Further evaluation will be required to determine the significance of such potential individual exposures.

MINERAL EXTRACTION INDUSTRY

Phosphate Mining and Milling

Numerous industries mine and process raw materials which occur in strata containing significant concentrations of uranium, thorium, and their daughter products. These include industries that are well established, currently mining and processing millions of tons of ore per year, such as the phosphate industry, as well as newly developed industries, such as geothermal power and oil shale.

While the naturally occurring radioactive materials are confined to depths of the earth, they cause little impact on man or the environment. This is because the surface environment is shielded from the radioactive materials by many feet of dirt and rock. However, the extraction of large quantities of the ores, their chemical separation, processing into commercial products, and distribution of the products result in situations where the radioactive components expose individuals and large populations.

The phosphate mining and manufacturing industry is representative of the general problem of redistribution within the environment of radioactive materials originating from beneath the earth's surface. In central Florida alone, there is approximately 30 million tons of phosphate rock processed per year (about 80% of the U.S. phosphate production). Field studies have shown that significant concentrations of uranium and thorium exist in various phosphate mine products and wastes. Table 5.3 presents the results of analytical determinations conducted by the Environmental Protection Agency's Eastern Environmental Radiation Facility for radium-226, uranium, and thorium concentrations in such products and wastes in Florida.

As the data show, the marketable rock and slimes contain more radium-226, uranium and thorium than do the sand tailings. This is because the radioactivity is directly associated with the

TABLE 5.3

RADIUM – 226, URANIUM AND THORIUM CONCENTRATIONS IN FLORIDA PHOSPHATE MINE PRODUCTS AND WASTES (20)

MATERIAL	RADIUM – 226 (pCi/GRAM)	URANIUM (pCi/GRAM)			THORIUM (pCi/GRAM)			
		234	235	238	227	228	230	232
MARKETABLE ROCK	42	41	1.9	41	2.0	.0.61	42.3	0.44
SLIMES	45	42	2.6	44	2.3	1.2	48	1.4
SAND TAILINGS	7.5	5.2	0.38	5.3				

TABLE 5.4

RADIUM – 226, URANIUM AND THORIUM IN WET PROCESS PHOSPHORIC ACID PLANT PRODUCTS AND BYPRODUCTS

MATERIAL	RADIUM – 226 (pCi/gm)	URANIUM (pCi/gm)			THORIUM (pCi/gm)			
		234	235	238	227	228	230	232
GYPSUM	33	6.2	0.32	6.0	0.97	1.4	13	0.27
NORMAL SUPER-PHOSPHATE	25							
DIAMMONIUM PHOSPHATE (DAP)	5.6	63	3.0	63	1.6	0.8	65	0.4
TRIPLE SUPER-PHOSPHATE (TSP)	21	58	2.8	58	1.2	0.9	48	1.3
MONOAMMONIUM PHOSPHATE (MAP)	5.0	55	2.9	55				
SODIUM FLOUROSILICATE	0.28							
ANIMAL FEED	5.5							
PHOSPHORIC ACID	840 pCi/l							

*PLANTS USING FLORIDA PHOSPHATE ROCK

phosphate compound structure, and the marketable ore and slimes contain most of the phosphate.

With 1973 production of 5.62 million tons of P_2O_5 as phosphoric acid, 20 million tons of marketable rock went to the production of phosphoric acid by the wet process method. This process results in the discharge of radium in liquid effluents, and significant radium and thorium concentrations in wet process phosphoric acid plant products and by-products. Data concerning these products gathered from several facilities using Florida phosphate rock are given in Table 5.4.

Phosphate manufacture results in the accumulation of massive gypsum piles (30–100 feet in height), the maintenance of large cooling ponds (about 500 acres), and the sale of fertilizer and other products all containing radioactive materials. The thermal milling process for the production of elemental phosphorus results in discharges of radioactive air effluents. However, most of the radioactivity originally in the ore is confined in the by-product calcium silicate slag. In addition, reclamation of mining areas results in creating land areas which contain substantially elevated soil radium concentration over normal soil. These lands are extensively used for residential and agricultural purposes (21).

The Environmental Protection Agency is actively pursuing programs in each of these potential problem areas. As far as radiation exposure in structures built on reclaimed land is concerned, EPA has joined the State of Florida in implementing a radiological survey of representative homes built on such land. Preliminary findings of this survey, published by the Agency in September 1975, suggest that "structures built on reclaimed land have radon daughter levels significantly greater than structures not built on reclaimed land" (22). Further radiological analysis will continue with TLD air pumps and track-etch film until a full year's exposure is available for study. Because of the concerns voiced by the public in the affected areas, EPA has established an interim guideline for new construction on reclaimed land. After a review of available data, the Agency made these recommendations to the State of Florida (23):

External Gamma Radiation Level	Recommendations
Equal or greater than 0.01 mR/hr	Construction should be delayed pending study or acceptable control technology should be instituted to preclude indoor radon daughter problems.
Less than .01 mR/hr	Construction may be initiated.

In order to assist further the State and local government in controlling this problem, the Office of Radiation Programs (ORP) has compiled a listing of recommended radon control measures to be employed in new home construction on phosphate lands. These recommendations include such control techniques as polymeric sealants, improved ventilation and columnar house supports. The selected control techniques used for each case depends primarily upon an external gamma radiation survey of the site.

In addition to performing radiation studies of structures, EPA has sampled fruits and vegetables grown on reclaimed land. As the citrus industry is one of the major land users in this region, a number of composite citrus samples have been collected for analysis.

Phosphate mining and milling effluents, both liquid and gaseous, are of major concern to EPA, State and local health officials because of their potentially high radium-226 content. Because of the potential for such releases, the Office of Radiation Programs has recommended for inclusion in the Final Radioactivity Effluent Guidance for Phosphate Chemicals and Fertilizer Manufacturing, the following standards for radium-226 in liquid effluent released to the environment: a daily maximum limitation of 9 pCi/liter total radium-226 and a monthly average limitation of 4 pCi/liter total radium-246 (24). Field and laboratory studies conducted by EPA have shown that with the "double-liming" treatment over 94 percent of the radium-226 is precipitated out of the effluent streams. These standards are based on the use of such treatment processes which are effective, but not unreasonable in cost to the industry. In order to monitor effluent seepage into nearby aquifers, EPA in conjunction with the State of Florida has sampled and analyzed numerous wells for radium-226. As for gaseous effluents, ORP-Las Vegas has been involved in stack sampling at phosphate milling plants in Idaho and EERF-Montgomery has been collecting data concerning radon emanation rates from gypsum piles.

Due to the size of the phosphate industry and the number of employees involved, occupational radiation exposure is an area which is being given a high priority for study at this time. Data on occupational radiation exposure levels associated with various job categories have been obtained. The goal of this occupational program is to identify those jobs with high radiation exposure levels and determine what control action is necessary.

EPA has been actively assessing several major phosphate products and by-products for potential radiation exposure to the public. By-products are of particular interest to the Agency because the vast amount produced and the radium-226 concentration inherent in most of them increase the likelihood of such exposure. By-product gypsum wallboard, for example, although not being manufactured in this country at this time, is also being similarly assessed at both EERF, Montgomery, and under contract with the Harvard University School of Public Health. The contract work at Harvard encompasses a wide range of construction materials, including wallboard.

Uranium recovery from phosphoric acid is an innovative technique which is just being commercialized on a wide scale at the present. This process, which utilizes solvent extraction of the uranium from the phosphoric acid process stream, holds great promise not only as a source of uranium, but also as a control measure for reducing the amount of uranium being released into the environment through fertilizers, and other phosphate products and wastes. EPA is presently assessing the radiological impact of this new industry on the environment and public health.

Although the phosphate mining and milling industry was first selected for concentrated effort by the Office of Radiation Programs, other mineral extraction industries also have a potential for contributing to occupational and public radiation exposure. One such industry is the mining of humates, a carbonaceous material used as a soil amendment which has shown above background concentrations of uranium. At the request of the Bureau of Land Management, EPA has assisted in the radiological impact assessment of the commercial sale of this material. EPA advised that the use of humate material with less than 30 ppm natural uranium in equilibrium with its daughters as proposed by the industry should not pose a significant adverse environmental and public health problem (25). Other ores such as copper, titanium and beryllium, depending upon mine location, have shown uranium concentrations high enough to be commercially extractable. At several copper mines in the southwest, in fact, such operations have been initiated as a result of an increase in the price of uranium. EPA is currently drafting development plans for these ores and has collected uranium concentration data through an outside contractor.

RADIOACTIVITY IN WATER

Drinking Water Regulations

Under the Safe Drinking Water Act of 1974, the Environmental Protection Agency is charged with setting limits for contaminants in drinking water. The Office of Radiation Programs has been involved in developing that portion of the Regulations which pertains to maximum contaminant levels for radioactivity. These regulations apply to public water systems having at least 15 service connections, or regularly serving at least 25 residents, on a year-round basis. Source waters for public systems may be divided into two broad categories: The first is ground water for which the most common radioactive constituent is naturally occuring radium-226. The second, surface water, is most often contaminated by artificially produced radionuclides – principally as a result of the atmospheric testing of nuclear weapons but also due to discharges from commercial nuclear facilities.

During the past year, EPA has reviewed data concerning present levels of both natural and artificial radioactivity in drinking water supplies. In addition, contracts studying the engineering and economic aspects of radium removal have been completed and monitoring techniques for both natural and artificial radionuclides have been evaluated.

Based on these data, proposed interim regulations for radioactivity in drinking water were published for comment in the *Federal Register* on August 14, 1975. Table 5.5 shows the maximum contaminant levels for radioactivity in Community Water Systems. During the comment period, following publication, a public hearing was held in Washington (September 10, 1975) and numerous written comments from the States, Federal agencies, municipalities, and the general public were received. A number of changes have been made in the proposed regulations in response to these comments and the revised regulations are now being reviewed prior to their promulgation in final form.

TABLE 5.5
MAXIMUM CONTAMINANT LEVELS FOR RADIOACTIVITY IN COMMUNITY WATER SYSTEMS

	Picocuries per liter
A. Of radium-226, radium-228, and gross alpha particle radioactivity	
(1) Combined radium-226 and radium-228	5
(2) Gross alpha particle activity (including Ra-226)	15
B. Of beta particle and photon radioactivity from man-made radionuclides	
(a) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water	

shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems.

EPA believes that these regulations will aid in achieving the national goal of safe drinking water.

Radon In Potable Water

ORP has recently begun evaluating the potential health significance of radon-222 which diffuses from potable ground water supplies used in family dwellings and commercial buildings. Present data indicate that one-third to one-half of all U.S. ground water supplies have radon-222 concentrations greater than 500 pCi/1. When this water is used in a home, especially with increased temperature and agitation, much of the radon could diffuse into the air. For a typical home using water with 500 pCi/1 of radon, the average air concentration could exceed 0.1 pCi/1. Continuous exposure at this concentration could result in an individual dose as high as 500 mrem to the tracheobronchial epithelium from inhalation of radon daughter products. The significance of such exposures to the U.S. population and relative control costs are the subject of the ongoing study. The results of this study should be available during 1976.

Water Quality Criteria

The Federal Water Pollution Control Act Amendments of 1972 require the Administrator of the Environmental Protection Agency to publish criteria for water quality. These criteria are far reaching in that the effects considered must pertain not only to humans but, also, to the total biota. In addition, the esthetic and recreational aspects of pollutants in water, including ground water, must be considered. The determination of water quality criteria is, therefore, a complex task which requires consideration of the interrelationships existing within the total aquatic ecosystem.

For radioactive substances, several criteria have been selected. These are basically for the protection of human health but also recognize that criteria stringent enough to protect human health should adequately protect the balance of the aquatic cycle.

Criteria for drinking water are the same as the Maximum Contaminant Levels proposed under Regulations called for by the Safe Drinking Water Act of 1974. Criteria to be considered in allowing the use of waters containing radioactivity for other purposes, such as the support of aquatic life, irrigation, and the watering of livestock, were guided by the principal that both individual and population doses should be considered. The Environmental Protection Agency recognizes that the wide range of the bioaccumulation factors for organisms in the food web precludes specification of generally applicable levels for radioactivity in water and has, instead, proposed criteria based on dose for elements in the food chain ingested by man.

Water Permit Program

No application of the Permit Program to discharges of man-made radioactivity has been made following the Administrator's decision not to designate as pollutants materials already regulated under the Atomic Energy Act. This decision has been contested by the Colorado Public Interest Research Group, Inc. and is now being considered by the U.S. Supreme Court following oral arguments held in December 1975. Discharges consisting of naturally occuring or accelerator produced radioisotopes are regulated under the Permit Program. For these materials both the

Environmental Protection Agency and the several States have issued discharge permits for liquid wastes.

U.S.-Canada Great Lakes Water Quality Agreement

The importance of the Great Lakes to both the United States and Canada has been recognized formally since signing of the Treaty of 1909 between the two countries. The original Treaty was reinforced, in 1972, by a subsequent Agreement, between the United States and Canada, to "restore and enhance water quality" in the Lakes. One of the general water quality objectives was that "radioactivity should be kept at the lowest practical levels and in any event should be controlled to the extent necessary to prevent harmful effects on health." One provision of the Agreement also required development of a more specific radioactivity objective.

As a consequence of the Agreement, an Advisory Committee, with members from both nations, was formed to consider a refined radioactivity objective for the Great Lakes. Co-chairmen were Dr. W. Mills from the Office of Radiation Programs of the United States Environmental Protection Agency and Dr. A. Booth from the Canadian Department of National Health and Welfare. A major portion of the staff work required by the Advisory Committee was carried out by the Criteria and Standards Division in the Office of Radiation Programs. In September 1975, a revised radioactivity objective was agreed upon by the Advisory Committee, consisting of members representing Nation, Provincial, and State governments, and forwarded to their respective Governments for further consideration.

This refined objective recommends that the level of radioactivity in Great Lakes water shall be such as to result in a dose equivalent to reference man of less than one millirem based on a standard annual intake. In addition, any release of radioactive materials shall be as low as reasonably achievable and is to be controlled by specified Action Levels. These Action Levels basically define the lake water radioactivity levels at which a particular source shall be investigated to insure that discharges are as low as reasonably achievable and a level at which corrective action shall be taken by the responsible national regulatory body.

The refined radioactivity objective, when ratified by both governments, will materially assist in preserving one of the major natural resources of both countries.

CONSTRUCTION MATERIALS

Construction materials may account for a significant exposure to the U.S. population from naturally occurring radioactivity. It has long been known that some building materials, such as granite, contain higher concentrations of uranium, thorium and their decay products (1). A notable example of increased radiation levels resulting from construction materials is buildings built on or adjacent to uranium mill tailings in Grand Junction, Colorado. Over 5000 buildings surveyed in the western United States have tailings incorporated in either the fill, grading, or concrete. Because the radon daughter activity levels in many of these buildings exceeded the Surgeon General's guide for such levels, a remedial program is presently underway to reduce the radon daughter levels in these structures. In Florida, Idaho and a few other states a similar situation exists with the use of phosphate slag material in concrete blocks and pavement. As part of the ongoing program in Florida, a determination is being made as to the extent of the problem and whether restriction will be necessary on the use of phosphate related materials for construction purposes.

In manufacturing phosphoric acid by the wet process, a large quantity of gypsum (calcium sulfate) is produced. To date, there has been a very limited market for this gypsum. Consequently, each phosphoric acid plant has a large store of gypsum typically between 50 to 300 acres about 50 to 100 feet high. Outside of the United States, where normal gypsum supplies are less abundant, a number of countries such as Germany and Japan, utilize by-product gypsum in wallboard construction. Preliminary data indicates that the by-product gypsum contains 20 to 43 pCi/gram of radium-226. In order to assess the potential radiation exposure to individuals living in structures constructed of such wallboard, the Environmental Protection Agency (EPA) will make dose measurements utilizing a test structure constructed with by-product wallboard which at this time is being shipped from Japan. In conjunction with these lab analyses, the Eastern Environmental Radiation Facility in Montgomery, Alabama, is developing a model for calculating internal doses due to radon emanation from by-product wallboard.

On June 27, 1975, EPA awarded the Harvard University School of Public Health, a contract to study radiation exposure due to building materials. It is expected that the final report will include a definitive report on the demographic variation for effective exposures of the population to natural radioactivity in building materials. Also included will be an estimate of factors which influence exposure and a methodology to describe population exposures due to the uranium, thorium, decay chain and potassium-40 which will include internal exposure due to radon and its daughters (26). The final report for this contract is being drafted.

REFERENCES

1. Gesell, T. and H. Prichard, "The Technologically Enhanced Natural Radiation Environment," *Health Physics*, April 1975.

2. U.S. Environmental Protection Agency. Environmental Radiation Protection for Nuclear Power Operations, Proposed Standards 40 CFR 190. Supplementary Information. Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460 (January 1976).

3. U.S. Environmental Protection Agency. Environmental Analysis of the Uranium Fuel Cycle, Part I—Fuel Supply, EPA-520/9-73-003B, Washington, D.C. 1973.

4. Kaufmann, R.F., G.G. Eadie, and C.R. Russell. Summary of Ground Water Quality Impacts of Uranium Mining and Milling in the Grants Mineral Belt, New Mexico, ORP/LV-75-4. U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas Facility, P.O. Box 15027, Las Vegas, Nevada 89114 (August 1975).

5. Summary Report. Phase I Study of Inactive Uranium Mill Sites and Tailings Piles (October 1974).

6. U.S. Environmental Protection Agency. Environmental Surveys of Uranium Mill Tailings Pile and Surrounding Areas, Salt Lake City, Utah, EPA-520/6-74-006. Office of Radiation Programs, Las Vegas Facility, Nevada (August 1974).

7. U.S. Environmental Protection Agency. Gamma Radiation Surveys at Inactive Uranium Mill Sites, ORP/LV-75-5. Office of Radiation Programs, Las Vegas Facility, Las Vegas, Nevada 89114 (August 1975).

8. Swift, J.J., J.M. Hardin, and H.W. Calley. Potential Radiological Impact of Airborne Releases and Direct Gamma Radiation to Individuals Living Near Inactive Uranium Mill Tailings Piles. U.S. Environmental Protection Agency, Office of Radiation Programs, Environmental Analysis Division, Washington, D.C. 20460 (January 1976).

9. Bernhart, D.E., F.B. Johns, and R.F. Kaufmann. Radon Exhalation from Uranium Mill Tailings Piles, Description and Verification of the Measurement Method, ORP/LV-75-7(A). U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas Facility, P.O. Box 15027, Las Vegas, Nevada 89114 (November 1975).

10. Hans, J.M.,Jr., and R.L. Douglas. Radiation Survey of Dwellings in Cane Valley, Arizona and Utah, for Use of Uranium Mill Tailings, ORP/LV-75-2. U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas Facility, P.O. Box 15027, Las Vegas, Nevada 89114 (August 1975).

11. Summary Report – Grand Junction Track Etch Demonstration Program. D.B. Lovett, General Electric Nuclear Energy Division, (December 1975).

12. "Control of Environmental Impacts From Advanced Energy Sources," EPA-600/2-74-002, Environmental Protection Agency, March 1974.

13. Gipsh, A.A. and G.G. Kapaturin, 1970, *Izv. vyssh. ucheb. Zaved.* 10, 195.

Jaworowski, A., J. Bilkiewica, L. Kownacka and S. Wlodek, 1972, Artificial Sources of Natural Radionuclides in the Environment, Natural Radiation Environment II, Proceedings of the Second International
Symposium on Natural Radiation Environment, Houston, TX, August 1972.

14. Eisenbud, M. and H.G. Retrow, 1964, *Science*, New York, 144, 288.

15. Martin, J.E., 1974, Comparative population radiation dose commitments of nuclear and fossil fuel elctric power cycles, in Proceedings 8th Midyear Topical Symposium of the Health Physics Society, CONF-741018, pp 317–326, NTIS, U.S. Department of Interior Open-File Report.

16. Swanson, V.E., C. Huffman, Jr., and J.C. Hamilton, Composition and trace-element content of coal, Northern Great Plains Area, Northern Great Plains Resource Program, Mineral Resources Work Group Report, February 1974, U.S. Department of Interior Open-File Report.

17. Trace element measurements at the coal-fired Allen steam plant, Progress Report: June 1971-January 1973, February 1973-July 1973, U.S. Atomic Energy Commission, Oak Ridge National Laboratory, ORNL-NSF-EP-43,62.

18. Johnson, R.H., Jr., D.E. Bernhardt, N.S. Nelson, and H.W. Calley, Jr. Assessment of potential radiological health effects from radon in natural gas, EPA-520/1-73-004. (November 1973).

19. Gesell, T.F., R.H. Johnson, Jr., and D.E. Bernhardt. Assessment of potential radiological health effects from radon in liquefied petroleum gas, EPA-520/1-75-002. Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. (In press)

20. Guimond, R.J. and S.T. Windham, Radioactivity Distribution in Phosphate Products, By-products, Effluents, and Wastes, U.S. Environmental Protection Agency, Office of Radiation Programs, ORP/CSD-75-3, August 1975.

21. Problem Resolution Plan, Population Exposure from Concentrations of Radioactive Material in Non-Nuclear Industry Processes, Effluents Residuals and Products, Category I: Phosphate Mining, Milling and Fertilizer Manufacturing.

22. Preliminary Findings Radon Daughter Levels in Structures Constructed on Reclaimed Florida Phosphate Land, U.S. Environmental Protection Agency, Office of Radiation Programs, ORP/CSD-75-4, September 1975.

23. Interim Recommendations for Gamma Exposure Levels at New Structures Sites on Florida Phosphate Lands (Draft), U.S. Environmental Protection Agency, Office of Radiation Programs.

24. Radioactivity Considerations for Effluent Guidelines for the Phosphate Mining Industry, Memo from William A. Mills, Director, Criteria and Standards Division, Office of Radiation Programs, to Allen Cywin, Director, Effluent Guidelines Division, U.S. Environmental Protection Agency, December 8, 1975.

25. Letter to R. Keith Miller, District Manager, U.S. Department of Interior, from William A. Mills, Director, Criteria and Standards Division, Office of Radiation Programs, U.S. Environmental Protection Agency, December 16, 1975.

26. Study of Radiation Exposures Due to Building Materials, EPA/68-01-3292, Contract schedule, Article II (Statement of Work), June 27, 1975.

OTHER NUCLEAR ENERGY ACTIVITIES – CHAPTER 6

INTRODUCTION

While many of the Federal Government's radiation protection activities focus on the nuclear fuel cycle per se, there are also many Federal radiation protection efforts associated with non-fuel cycle activities. Monitoring and surveillance of a wide range of nuclear radiation sources account for a major portion of these Federal program activities. Included also are quality assurance programs aimed at improving the accuracy in radiation measurements by Federal and State agencies and by industry.

Emergency response planning for radiological incidents is a problem that involves cooperative efforts of Federal and State agencies. Because of public concern over the potential consequences and environmental impact, increased efforts in this area were initiated in 1975.

A wide variety of non-conventional nuclear projects have come under Federal supervision and control. Significant 1975 activities in this area centered around plutonium powered cardiac pacemakers, spark cap irradiators containing cobalt-60, fusion reactor experiments, and uranium enrichment.

This chapter discusses the 1975 radiation protection events concerned with non-nuclear fuel cycle activities.

ENVIRONMENTAL ASSESSMENT

Dose Assessment Program

EPA's Office of Radiation Programs (ORP) has initiated a National dose assessment program (1) to determine the status of environmental radiation data, to analyze these data in terms of individual and population doses, and to provide guidance for improving radiation data. In addition, this program will provide information to guide the direction of ORP by the analysis of radiation trends, identification of radiation problems, and support for establishing radiation protection guidance. The general approach in this program is to make maximum use of available data reported by others and updated by EPA. Additional data are acquired from EPA's Environmental Radiation Ambient Monitoring System (ERAMS), source related field studies, and dose computational models. The gathering of such a total data base for radiation dose assessment in the United States in unique to EPA.

Environmental Radiation Ambient Monitoring System (ERAMS)

ERAMS is a program for continuing surveillance of radioactivity levels throughout the continental United States, Alaska, Hawaii, and U.S. territories. Through this system, over 7,000 individual analyses are performed annually on samples of air, airborne particulates, deposition, surface and drinking water, milk, and human bones. These samples are collected by State and local health agencies and analyzed at ORP's Eastern Environmental Radiation Facility (EERF) at Montgomery, Alabama. The present ERAMS emphasis is towards identifying trends in the accumulation of long-lived radionuclides in the environment. Therefore, specific analyses are made for uranium-234, uranium-238, plutonium-238, plutonium-239, carbon-14, tritium, strontium-90, and krypton-85. Measurements are also made for gross alpha and beta activity, and the gamma emitters, iodine-131, cesium-137, barium-140, and potassium-40.

Data from ERAMS were previously published in *Radiation Data and Reports*; however, the Office of Radiation Programs terminated this publication with the December 1974 issue. Since then a quarterly summary of raw data from the National Environmental Radiation Ambient Monitoring System network (which includes a limited amount of surveillance data from States) is reported in *Environmental Radiation Data*.* These compendiums consist mainly of data tabulations without interpretation or discussion. These tabulations will be summarized annually and reported in ORP's report on the *Radiological Quality of the Environment*. An in-depth analysis of ERAMS is being carried out to determine annual averages, to identify trends, to characterize the statistical distributions of data sets, to estimate individual and population doses, and to evaluate error terms for each of these determinations.

Beginning with data from samples collected in July 1975, all ERAMS data will be reported according to a new protocol. The most significant change is that specific radionuclide analyses will be reported as the counting results indicate, whether the number is negative, zero, or positive. Ambient concentrations of nuclides are frequently at or near zero. When the actual concentration of a nuclide is zero, the counting results should statistically show a distribution of negative and positive numbers near zero. Previously ERAMS data were not reported numerically when the results were less than a specified reporting level. The new reporting protocol allows all data to be evaluated statistically without an arbitrary cutoff of small or negative numbers. This will facilitate estimates of bias in the nuclide analysis and will allow better evaluations of distributions and trends in environmental data.

*Environmental Radiation Data is available from: Environmental Protection Agency, Eastern Environmental Radiation Facility, P.O. Box 3009, Montgomery, Alabama 36109. Each quarterly summary must be requested separately as a mailing list is not being prepared.

Radiological Quality of the Environment

ORP has initiated a project for evaluating annually the radiological quality of the environment as a part of the dose assessment program. The first prototype report for this project is intended to summarize individual and population dose data for two source categories of radiation, ionizing and nonionizing. The primary effort for the first report was to identify source categories of ionizing radiation. Sources in the ionizing category have been grouped under ambient environment, technologically enhanced natural radiation, fallout, uranium fuel cycle, Federal facilities, medical, occupational, and other miscellaneous sources. The nonionizing radiation category is mainly concerned with environmental sources.

Literature searches have been conducted for each of those sources and the data organized to provide the following information: 1) general information about each source category and availability of data, 2) data base description, 3) status of data base analyses, 4) summary of dose data for each source, 5) comparison of reported dose data with estimates from previous publications, 6) discussion and conclusions.

The first annual *Radiological Quality of the Environment* report will be available from the Office of Radiation Programs about June 1976 (2).

However, Table 6.1 summarizes the individual and population doses in the U.S. from each category of radiation source discussed in the report. The information is divided according to the primary mode of exposure: external—which results in a radiation dose to the whole body, or internal—when radioactive materials are inhaled, ingested or occasionally absorbed through the skin and often result in a radiation dose to particular organs of the body.

It should be noted that although population doses from the different source categories, in general, can be added together to gain a perspective of overall impact, it does not necessarily follow that individual doses can be added together because an individual in one population group generally does not receive the radiation dose common to another population group. For this reason, the data in this table show total population doses in the various source categories.

The dose of approximately 10 million person-rem per year from ambient ionizing radiation greatly exceeds each of the other categories of radiation sources. The second largest category of population dose is from the use of radiopharmaceuticals for medical radiation purposes, estimated at 3 million person-rem per year; the next largest dose category is from technologically enhanced natural radiation, contributing approximately 3 million person-rem per year and also contributing to the largest individual dose.

Improvement in Surveillance Programs

Part of ORP's dose assessment program is oriented towards improving the quality of surveillance data. A facility data analysis project was developed for this purpose. This project will evaluate the rationale for surveillance programs, as well as details in program planning and design, sampling methodology, radioassay techniques, quality assurance, and data handling, reporting, and interpretation. Early phases of the project have dealt with criteria for summarizing and using ambient data, development of data analysis techniques, dose conversion criteria, and

TABLE 6.1 RADIOLOGICAL QUALITY OF THE ENVIRONMENT

Summary of Dose Data from All Sources

SOURCE	EXTERNAL		INTERNAL	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Ambient Ionizing Radiation	-	9.7×10^6	-	-
Cosmic radiation	40.9-45	9.7×10^6	-	-
Ionizing component	28-35.3	9.2×10^6	-	-
Neutron component	0.33-6.8	4.9×10^5	-	-
Worldwide radioactivity				
Tritium	-	-	0.04	9.2×10^3
Carbon-14	-	-	1.0	-
Krypton-85	4×10^{-4}	80	-	-
Terrestrial radiation	30-95	-	18-25	-
Potassium-40	17	-	16-19	-
Tritium	-	-	4×10^{-3}	-
Carbon-14	-	-	1.0	-
Rubidium-87	-	-	0.6	-
Polonium-210	[a]13	-	2-3	-
Radon-222	[b]25	-	3.0	-
Technologically Enhanced Natural Radiation	-	-	-	2.73×10^6
Ore mining and milling	-	-	-	-
Uranium mill tailings	-	-	[c]140-14000	[d]2.5-70000
Phosphate minining and processing	-	-	-	-
Thorium mining and milling	-	-	-	-
Radon in potable water supplies	-	-	-	-
Radon in natural gas	-	-	[e]54	2.73×10^6
Radon in liquified petroleum gas	-	-	0.9-4.0	30000
Radon in mines	-	-	-	-
Radon daughter exposure in natural caves	-	-	-	-
Radon and geothermal energy production	-	-	-	-
Radioactivity in construction material	-	-	-	-

TABLE 6.1 RADIOLOGICAL QUALITY OF THE ENVIRONMENT

Summary of Dose Data from All Sources (Continued)

SOURCE	EXTERNAL		INTERNAL	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Fallout	f 2	-	-	-
Uranium Fuel Cycle	-	2014	-	-
Mining and milling	-	-	84.5x10^{-2}	2.5
Fuel enrichment	^{h}0.17	14	^{i}4.8-8.0	^{j}14
Fuel fabrication	-	-	^{k}2x10^{-3}	^{k} 3
Power reactors BWR	^{m}54 max	^{n}1552	-	-
PWR	^{m} 1 max	^{n} 155	-	-
Research reactors	-	-	-	-
Transportation -				
Nuclear power industry	-	^{o} 100	-	-
Radioisotopes	-	^{o} 170	-	-
Reprocessing and spent fuel storage	^{p}5.8	^{p} 23	-	-
Radioactive waste disposal	-	-	-	-
Federal Facilities	-	1.96	-	-
ERDA	^{m}13-320	^{n}8x10^{-7} -1.96	-	-
Department of Defense	0.01	-	-	-
Accelerators	^{m}0.04-4	0.42-65	-	-
Radiopharmaceuticals-production and Disposal	0.2	^{q}0.083	-	-

TABLE 6.1 RADIOLOGICAL QUALITY OF THE ENVIRONMENT

Summary of Dose Data from All Sources (Continued)

SOURCE	EXTERNAL		INTERNAL	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Medical Radiation				
X radiation	[r]20	-	-	-
Radiopharmaceuticals	-	-	-	[s]3.3×10^6
Occupational and Industrial Radiation				
BWR	[t]1230	-	-	-
PWR	[t]1080	-	-	-
All occupations	[u]0.80	-	-	-
Consumer Products	-	6100	-	-
TV	[v]0.025-0.043	-	-	-
Timepieces	-	6100	-	-
	Individual Exposure ($\mu W/cm^2$)			
Nonionizing Electromagnetic Radiation				
Broadcast towers and airport radars	10			
All sources	0.1-1			

TABLE 6.1 RADIOLOGICAL QUALITY OF THE ENVIRONMENT

KEY

a Uranium-238 series
b Thorium-232 series
c Lung dose
d Lung-rem/y
e Trachea-bronchial dose
f 50 year dose commitment divided by 50
g Average individual lung dose within 80 km
h Maximum potential exposure
i Maximum potential exposure to lung
j Cumulative exposure within 40 mile radius
k Average individual lung dose within 80 km
m Fence line boundary dose
n Within a radius of 80 km
o Estimated for the year 1973
p For NFS
q Based upon data from 5 institutions
r Millirads/y
s Estimated 1980 dose
t Average occupational exposure/y
u Average exposure for all occupations & 3.7 radiation workers/1000 persons in United States
v 5 cm from TV set; units of mR/h
- = No dose data available

the development of a manual on sampling methodology. Information from these initial phases will be used to evaluate surveillance programs at several commercial and Federal nuclear facilities. These reviews will aid in developing criteria for the evaluation of surveillance programs and later will lead to an updating of EPA's *Environmental Radiation Surveillance Guide* (3).

Dose Modeling

ORP has an ongoing program to develop exposure pathway models for estimating individual and population doses from facility effluents. The emphasis is on long-term population dose commitment and health risks. One of the primary exposure pathways for nuclear power plants is from gaseous effluents. ORP has developed a model called AIREM (4) to evaluate the air pathway by estimating doses from inhalation and external radiation. Other dose models have been developed for radionuclide releases to rivers and for the airborne dispersion, deposition, and resuspension of plutonium particles. A model has also been developed for ground level area sources of radon and particulates from tailings piles in the uranium and phosphate industries. Reports on each of these models are in preparation and should be available during 1976.

QUALITY ASSURANCE

Since EPA's emphasis in its dose assessment program is on maximizing the use of radiation surveillance data reported by others, there is much concern for validation of such data. To aid laboratories in maintaining the accuracy and precision of their analyses, EPA operates a Radiation Quality Assurance Program through the Environmental Monitoring and Support Laboratory in Las Vegas. The two major activities of this program are the distribution of radionuclide reference standards (5) and environmental media containing known amounts of one or more radionuclides (6). This program is available to all Federal, State, local, and private laboratories. During 1975, the Nuclear Regulatory Commission (NRC) expressed an interest in having their licensees and contractor laboratories participate in EPA's Quality Assurance Program. An Interagency Agreement between EPA and NRC is now being written to formalize this participation.

An increasing number of elements discharged into the environment are being scrutinized for possible environmental effects. These include heavy elements as well as certain radionuclides. Since a large number of the samples to be analyzed consist of plant or animal tissue, an effort is underway by the EPA's Environmental Monitoring and Support Laboratory (EMSL) in Las Vegas to prepare standard reference materials which contain in vivo pollutants. This material resembles the samples to be analyzed more closely than does material to which the pollutants are physically added. Mercury. lead, arsenic, and cadmium have been chosen as candidates for incorporation into plant materials.

New reference materials are being made available. In final preparation are the uranium-235/-238 series, thorium ore, uranium mill tailings, and radium-bearing soil. These are needed for calibration, standardization, yield determination, and quality control acitvities in radiation monitoring laboratories. These reference materials will aid in EPA's operational monitoring programs in acquiring accurate and legally defensible ambient and source environmental quality data. The reference materials are presently undergoing final checks for homogeneity and accuracy of analyses and will be available in early 1976 upon request to all Federal, State, Regional, and private laboratories engaged in monitoring and enforcement activities.

Mancos shale obtained from Grand Junction, Colorado, has been processed and blended to ensure homogeneity. This soil is presently being characterized for radium and other probable radionuclides by the National Bureau of Standards and should also be available in early 1976.

The methodology required for preparing representative samples containing known amounts of plutonium and americium has been developed. Samples will be prepared according to this methodology and distributed to other laboratories for use as a yardstick by which the accuracy of their radiochemical analyses can be evaluated.

To assist laboratories involved in environmental radiation measurements to develop and maintain a control program, extensive laboratory intercomparison studies involving environmental media (milk, water, air, food, soil, and gases) and a variety of radionuclides with activities at or near environmental levels are being made. The types of cross-check analyses and the number of participating laboratories are shown in Table 6.2.

TABLE 6.2 NO. OF PARTICIPATING LABORATORIES IN CROSS CHECK ANALYSIS - 1975

Type of Cross-check	October	November	December
Gamma in water	65	—	67
Tritium in water	67	—	72
Milk	—	61	—
Gross alpha and gross beta in water	—	58	—
Radium-226 in water	—	27	—
Air Filter	—	—	52
Diet	—	—	23
Tritium in urine	—	—	14

The laboratories participating in the programs include 2 international, 13 Federal, 43 State, 13 university, and 46 nuclear facilities and contractor laboratories.

To meet the needs of environmental monitoring laboratories, new studies are periodically introduced into the program. Currently, in response to requests from participants, an air sample containing krypton-85 is being prepared for use both as a reference sample, and for use in the cross-check program. Although krypton-85, a noble gas, has a much lower radiotoxicity than many other radioisotopes, the multi-curie amounts being released to the environment make it a pollutant of concern to the EPA. Preparation of the krypton-85 samples, which will be available for distribution early in 1976, required the design, construction, and testing of a complex gas system. This system mixes known amounts of krypton-85 and air and transfers accurately measured aliquots of the gas mixture into small refillable metal cylinders. The system also separates krypton from air for analysis by either liquid scintillation counting of krypton-85, or for the measurement of stable krypton and krypton-85 by a gas chromatograph-radiation detection system.

EPA prepares and distributes calibrated low-level radioactive solutions to Federal, State, and private laboratories involved in environmental radiation monitoring and surveillance. These solutions are utilized for both the calibration of counting instruments and chemical yield determinations. Since the laboratories using these samples must have confidence in their accuracy, EPA has instituted intercomparison studies with the National Bureau of Standards (NBS) and with the Energy Research and Development Administration's Health Services Laboratory.

The results of the studies conducted with the NBS during 1974 and 1975 are described in detail in the Environmental Monitoring Series publication entitled, "Radiation Quality Assurance Intercomparison Studies" (EPA-600/4-75-014, October 1975).

Environmental measurements are made daily by many different Federal, State, local, and private agencies. The data from these measurements are used for a wide variety of purposes including assessment of health effects, the establishment of standards and guides, and for enforcement activities. It is therefore imperative that the precision and accuracy of the data be assured in order that policy decisions concerning environmental quality be based on valid and comparable data.

As an integral part of its overall quality assurance effort, the EMSL prepares and distributes a variety of calibrated low-level radioactive samples for use in the laboratories of Federal, State, local and private agencies. The major objective of this program is to encourage the development of intralaboratory and interlaboratory quality control procedures and thus ensure that environmental radiation data are valid. Providing accurately calibrated samples assists laboratories in calibrating new instruments, implementing and maintaining routine instrument calibration programs, evaluating analytical procedures, and developing and revising data processing programs.

EMERGENCY RESPONSE PLANNING ACTIVITIES

The responsibilities of certain Federal agencies with regard to radiological incident emergency response planning for fixed facilities and transportation, including provisions for planning assistance to State and local goverments, were defined in a *Federal Register* Notice initially issued in 1973 and revised in December 1975 by the Federal Preparedness Agency in the General Services Administration.(7)

As the "lead agency" in the Federal interagency program spearheading this effort, the Nuclear Regulatory Commission during 1975 actively assisted State and local governments in developing and improving such emergency response plans. Other Federal agencies engaged in this program are the Environmental Protection Agency, the Defense Civil Preparedness Agency, the Energy Research and Development Administration, the Federal Disaster Assistance Administration, the Department of Transportation, and the Department of Health, Education, and Welfare. Responsibilities are assigned by the Federal Preparedness Agency of the General Services Administration.

During the year, NRC formally reviewed 25 State radiological emergency response plans, following up in each case with specific guidance for improvement. A "Field Training Cadre," made up of representatives from NRC and other Federal agencies, visited 17 States to provide direct assistance. Similar "cadres" evaluated actual field tests of emergency plans in six States.

In the area of training, the "Federal Interagency Course in Radiological Emergency Response Planning" was established by NRC and other Federal agencies at the Defense Civil Preparedness Agency Staff College in Battle Creek, Michigan. Approximately 125 State and local government emergency planning personnel have attended the course through fiscal year 1976 and beyond.

NRC and other Federal agencies are developing a second course in "Radiological Emergency Response Operations" to be offered to State and local government personnel during 1976.

EPA responsibilities include the establishment of Protective Action Guides (PAG) and the recommendation of appropriate protective actions to ameliorate the consequences of a radiological incident. A protective action is an action or measure taken to avoid or reduce the exposure to radiation from inadvertent release of radioactive materials. The term Protective Action Guide is defined as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event(8,9). The projected absorbed dose is the dose that would be received by individuals in the population group from the contaminating event if no protective action were taken. If the projected dose exceeds the PAG, protective action is indicated. The nature of the protective action, under any specific circumstance, may vary depending on the nature of competing risks. The preferred protective action may not be called for in all circumstances. In some cases, a variety of protective actions may be indicated.

In the event of a nuclear incident with subsequent releases of radioactive material, there will be a hazard from airborne material and from contamination of foodstuffs and property. The three most critical pathways of exposure then would be (a) direct exposure from cloud or plume passage, (b) exposure from foodstuffs, and (c) exposure from contaminated property or equipment. These pathways are being investigated to determine appropriate PAG's(8,9,10).

The protective measures considered appropriate for achieving the objectives of the Protective Action Guides include evacuation, sheltering, prophylaxis, respiratory protection, and controlled access. Evacuation is effective for protection against any radiation exposure. Sheltering is considered, but it is probably ineffective against continuous gaseous releases after about two hours in the absence of shelters with ventilation control. Prophylaxis may be necessary to provide blocking of the thyroid; however, because of some potential side effects, this may not be advisable. If appropriate, apparatus can be provided for respiratory protection for some individuals. Finally, controlled access to affected areas is effective in preventing additional members of the public from being significantly exposed.

EPA has developed recommended Protective Action Guides for emergency response for whole body external exposure to airborne radioactive materials (Table 6.3). These guidelines represent numberical values as to when, under the conditions most likely to occur, intervention is recommended to avoid radiation exposure that would otherwise result from the incident. Due to the ability of the thyroid to concentrate iodine, the thyroid dose due to inhaling radioiodine may be hundreds of times greater than the corresponding whole body external dose. The Protective Action Guide recommended by EPA for thyroid dose due to inhalation is also listed in Table 6.3.

Within the framework of these guides, it is assumed that: (a) the PAG's apply to acute exposure from a gaseous cloud released to the atmosphere from a light water nuclear reactor accident, and (b) the PAG's apply only to the taking of initial protective actions within the first 2 to 4 days after an accident; decisions as to later protective actions or cessation of actions under specific situations are left to the responsible officials.

TABLE 6.3

PROTECTIVE ACTION GUIDES FOR WHOLE BODY AND THYROID EXPOSURE TO AIRBORNE RADIOACTIVE MATERIALS

Population at Risk	Projected Whole Body Gamma Dose (rem)	Projected Thyroid Dose (rem)
Nonessential personnel	1 to 5(a)	5-25
Emergency workers	25	125
Lifesaving activities	75	(b)

(a)When ranges are shown, the lowest value should be used if there are no major local constraints in providing protection at that level, especially to sensitive populations. Local constraints may make lower values impractical to use, but in no case should the higher value be exceeded in determining the need for protective action.

(b)No specific upper limit is given for thyroid exposure since, in the extreme case, complete thyroid loss might be an acceptable penalty for a life saved. However, this should not be necessary if respirators and/or thyroid protection for rescue personnel are available as a result of adequate planning.

EPA Manual of Protective Action Guides and Protective Actions For Nuclear Incidents (11)

This Manual has been prepared to provide practical guidance to State, local, and other officials on criteria to use in planning for radiological emergencies that could present a hazard to the public. It provides a perspective for protective actions and guidance for planning and implementation of protective actions to protect the public in the event of a nuclear incident. Recommendations on the application of Protective Action Guides and protective actions are being developed separately for various categories, such as (a) exposure to airborne radioactive materials, (b) exposure from foodstuffs or water, (c) exposure from material deposited on property or equipment, and (d) transportation incidents.

The manual has been issued to help State and local officials develop adequate emergency response plans and to ensure that prompt responses will be made—even though the probability of an incident requiring such actions is extremely low.

The EPA manual calls for responsible State and local agencies to secure agreements with nuclear power facility operators to promptly notify them if an accident occurs which could potentially expose the population to radiation levels above those specified by EPA. These action levels are above those normally experienced, but below those which would rapidly cause detrimental effects in individuals.

Following notification by the nuclear facility operator, the first protective actions, such as possible evacuation and/or instructions to the public to take cover in the nearest buildings and stay indoors, would be implemented by State and local officials. At the same time, survey teams would be dispatched by State or local officials to make radiation measurements that could be used to evaluate the need for changing the size or location of the area needing protective action. Emergency teams would also be dispatched to implement protective actions and to restrict access to the affected area.

After the potential exposure to elevated levels of airborne radioactivity has ended and the need for protective actions relative to this exposure have ended, continued controls on the use of food and water might be necessary, and some surfaces, such as streets, buildings, and cars might require decontamination.

During 1975, EPA continued to study the relative benefits of shelter and evacuation as protective actions, and the cost-risk-benefit of protective actions for exposure from deposited radioactive material. Two appendices to the manual were drafted and started through the review process. One of them provides guidance for offsite emergency radiation measurement systems, and the other provides the technical basis for dose projection techniques that were used in the manual.

In a related activity the Interagency Task Force on Offsite Emergency Instrumentation for Nuclear Incidents at Fixed Facilities produced a draft report on measurement systems for an airborne plume.

EPA also participated in the Interagency Task Force on Training and Exercises and, as a result, assisted in developing training programs for State and local response planning and participated in conducting these training programs. As a part of this function, EPA has taken the lead in developing a training course for State Radiological Emergency Response coordinators.

SPACE APPLICATIONS

Launch of SNAP Systems

Launches of two identical spacecraft, Viking A and Viking B, were made during 1975. Each of these spacecraft contained 20,000 curies of plutonium in a Space Nuclear Auxiliary Power System (SNAP). The first launch was August 21 and the second September 9. These space vehicles are to make soft landings on the surface of Mars in midsummer 1976.

In order to assess any release of radioactive material, a monitoring program is conducted by five mobile teams with instrumentation in the immediate launch area. The program is directed from the launch control center by a senior Environmental Protection Agency officer. EPA's Eastern Environmental Radiation Facility routinely provides support to the National Aeronautics and Space Administration and the Department of Defense during the launch of vehicles carrying SNAP units. In the event of a near-pad abort, with a land or water impact, EPA will support, with information and consultation, the control and management of radiological threats to the environment. EPA also serves as a liaison between the launch agency and State and local health agencies.

Environmental Impact Statements for Space Vehicles

During 1975, the Air Force prepared a draft and a final environmental statement on the Lincoln Experimental Satellites 8 and 9 (LES 8 and LES 9). To be launched into terrestrial orbits, these twin satellites will be powered by thermoelectric generators containing a total of over 300,000 curies of plutonium, a larger quantity than the total present atmospheric inventory from all testing of nuclear weapons. A potential radiation exposure and health effects from plutonium releases would exist if the launch were to abort, or the satellite to fail to reach orbit. It is essential to make this potential a minimum by appropriate design.

Evaluation of nuclear safety was carried out by an Interagency Nuclear Safety Review Panel composed of representatives from ERDA, NASA, and DOD. The safety review resulted in a Safety Evaluation report by the INSRP in July 1975. A final environmental statement, with review comments by EPA and others, was published in December 1975.

Unlike plutonium-239, plutonium-238 is not sufficiently fissionable to support a chain reaction, but is an alpha particle emitter and therefore a radiation and heat source. A rugged, multiple-jacketed design was used to prevent dispersion of this fuel in the event of a crash. The fuel, as plutonium dioxide, was pressed into 250 gram solid spheres, covered with iridium impact shells, and further covered with 0.46 in. thick graphite impact shells. Each source contains 24 of these assemblies in a graphite cylinder with iridium cladding. Structural integrity is provided by the iridium components, while impact energy is taken up by the graphite components and additional crush-up material in the cylinder.

The LES 8 and 9 were successfully launched together and placed in orbit in March 1976, to remain there indefinitely.

NUCLEAR WEAPONS TESTING

The major issue concerning nuclear weapons testing is the continued atmospheric testing by countries not signatory to the Threshold Test Ban Treaty. On July 3, 1974, the United States and Soviet Union signed The Treaty on the Limitation of Underground Nuclear Weapons Tests. This

Treaty states in part that "Each party undertakes to prohibit, to prevent, and not to carry out any underground nuclear weapons tests having a yield exceeding 150 kilotons at any place under its jurisdiction or control, beginning March 31, 1975. Those nuclear detonations detected and reported during 1975 are included in Table 6.4.

TABLE 6.4

NUCLEAR DETONATIONS DURING 1975

Date (1975)	Country	Test Area/NAME	Yield Range (kilotons
20 February	USSR	Semipalatinsk	20-200
28 February	US	Nevada/Topgallant	20-200
7 March	US	Nevada/CABRILLO	20-200
11 March	USSR	Semipalatinsk	20-200
5 April	US	Nevada/DINING CAR	Less than 20
24 April	US	Nevada/EDAM	20-200
27 April	USSR	Semipalatinsk	20-200
30 April	US	Nevada/OBAR	20-200
14 May	US	Nevada/TYBO	200 KT to 1 MT
3 June	US	Nevada/STILTON	20-200
3 June	US	Nevada/MIZZEN	20-200
7 June	USSR	Semipalatinsk	20-200
19 June	US	Nevada/MAST	200 KT to 1 MT
26 June	US	Nevada/CAMEMBERT	200 KT to 1 MT
6 August	USSR	Semipalatinsk	20-200
23 August	USSR	Novaya Zemlya	Multi-megaton
6 September	US	Nevada/MARSH	Less than 20
24 October	US	Nevada/HUSKY PUP	Less than 20
26 October	China	Lop Nor	Less than 20(underground.
28 October	US	Nevada/KASSERI	200-1000
28 October	USSR	Semipalatinsk	20-200
20 November	US	Nevada/INLET	200-1000
26 November	US	Nevada/LEYDEN	Less than 20
20 December	US	Nevada/CHIBERTA	20-200
25 December	USSR	Semipalatinsk	20-200

ENVIRONMENTAL IMPACT STATEMENTS (EIS)

Plutonium Powered Cardiac Pacemakers

The draft generic DEIS on the wide-scale use of plutonium powered cardiac pacemakers was issued by the U.S. Atomic Energy Commission (AEC) in January 1975. Prior to this action the AEC had issued licenses for the manufacture of plutonium powered pacemakers, but only on a limited basis, in order to establish safety and reliability data. The purpose of the DEIS was to analyze the data and other factors by considering radiation safety, benefits resulting from the comparatively long half-life of plutonium "batteries," alternative types of pacemakers, and risks to the public and the environment to enable a decision to be made whether to issue licenses for larger scale production.

The EPA comments were issued the following month and, in general, found the DEIS comprehensive and acceptable. However, it was felt that there should have been a deeper discussion on alternative, non-nuclear pacemakers and comment was made on the lack of any discussion dealing with a security system to safeguard the plutonium. The AEC was urged to include such a discussion in the DEIS. Also, the AEC's cost-benefit analysis was questioned as to its validity, and some suggestions were made to improve it.

Licensing Exemption for Spark-Gap Irradiators Containing Cobalt-60 (NUREG-75/086)

In October 1975, the U.S. Nuclear Regulatory Commission (NRC) issued a DEIS concerning a proposed amendment to NRC regulations to exempt from requirements for a license the receipt, possession, use, transfer, export, ownership, or acquisition of spark-gap irradiators that contain cobalt-60 (Co-60) for use in spark-ignited fuel-oil burners. Each irradiator would have a quantity limit of 1 microcurie of Co-60. As the draft statement indicates, the NRC staff concluded that the exemption of such irradiators may be: "(a) appropriately conditioned to protect environmental values; and (b) acceptable for consideration by the Commission as a proposed amendment to 10 CFR Part 30 under the Commission's rules of practice regarding rule making petitions and the provisions of the Administrative Procedure Act related to rule making."

EPA stated that the draft statement does not adequately support the conclusion reached by the NRC staff since it does not adequately address the potential environmental impact of the proposed exemption or sufficiently explore alternatives. Also, the cost-benefit analysis presented in the statement was determined to be inadequate and it was recommended that this section be redone to more realistically address and document the benefits and costs to society and the environment that could result from the proposed exemption. Other EPA comments discussed the need to include operating experience information on the irradiators, reexamine the scope of the proposed exemption and expand the radiological impact analysis to include estimates of population dose and a more thorough discussion of potential accident situations.

Moreover, EPA commented that the draft statement does not provide the required strong technical documentation which demonstrates that a significant benefit would be derived from the use of the irradiators and that a non-radiological alternative could not be utilized to achieve the same result. However, based on the limited information presented, EPA concluded that the minimal benefit of the proposed exemption does not appear to justify the radiation dose to the installers and disposal personnel and potential dose to other members of the general public from lost or misplaced Co-60 irradiators.

Tokamak Fusion Test Reactor

The TFTR Facilities DEIS was issued in February 1975, in support of the Energy Research and Development Administration's proposal for legislative authorization and appropriations for the TFTR project. The TFTR, to be built at the Princeton Plasma Physics Laboratory, will be the first United States fusion reactor designed to achieve break even conditions where the fusion energy produced will equal the energy supplied to heat the plasma. As such it will provide important plasma physics and engineering information for subsequent design of an experimental Fusion Power Reactor utilizing the Tokamak magnetic confinement system. Plans call for initial operation in 1980 with five years of experimental operation.

The draft statement, as support for legislation, drew largely from conceptual designs. Therefore, some of the information necessary to arrive at a conclusive evaluation of environmental impacts was not available. For that reason, EPA requested that provisions be made to ensure that the tentative conclusions reached in the statement are reviewed as the design is refined and that any significant results be published prior to facility operation. In the final statement on July 1975, ERDA agreed to such a review procedure.

Expansion of U.S. Uranium Enrichment Capacity (ERDA-1543)

This DEIS was prepared in support of ERDA's administrative actions related to expansion of the U.S. uranium enrichment capacity and the President's message and legislative proposal sent to Congress on June 26, 1975.

The DEIS assesses the foreseeable environmental, social, economic, and technological costs and benefits of this expansion along with available alternatives to such expansion. The current production capacity for enriching uranium for commercial nuclear power plants is fully committed to existing and planned domestic and foreign reactors.

The postulated expansion required to support nuclear power growth through the year 2000 is eleven enrichment plants, each of which is equivalent in capacity to an existing U.S. uranium enrichment plant.

In EPA's review of the DEIS an attempt was made not only to assess the adequacy of the statement as presented but also to apply some philosophy for priority setting for overall nuclear fuel cycle needs. EPA believes that this is necessary in the case of such broad expansion of the uranium enrichment part of the nuclear fuel cycle as proposed by ERDA.

The following principal conclusions were reached during the review: (1) a nuclear enrichment program can be conducted with an acceptable environmental impact, (2) reassessment of nuclear fuel cycle priorities is necessary to facilitate a smooth domestic program, (3) definition and classification of enrichment wastes and of associated waste management practices should be improved, and (4) enrichment plant dose assessment must be done on a site dependent basis using local meteorology.

Underground Nuclear Testing Program (Supplement to WASH-1526)

The ERDA Draft Supplement to the April 1973 Final Environmental Statement, Underground Nuclear Testing Program (WASH-1526) reassessed the environmental aspects of the underground nuclear testing program at the Nevada Test Site for fiscal year 1976 and the transitional period to assure that further major testing activities would have minimal adverse environmental impacts. The statement addressed those environmental consequences at the outset or at each stage of the testing program to serve as a base for evaluating the environmental impact of future actions in relation to the existing environment at the Nevada Test Site and surrounding area. In its review, EPA attempted to determine whether the information provided was complete and adequate to support the conclusions reached. In addition, EPA evaluated the current ERDA radiation monitoring program to determine if contamination is presently reaching the environment (and if so, in what quantities) and if the ERDA monitoring program has the capability to predict the present and future impact of underground nuclear testing on the environment.

EPA recognized that this program has been conducted in the past without major environmental proglems, and believes that its continuation during fiscal year 1976 and the transitional period can likewise be carried out safely.

The final FY 1976 Supplement EIS was issued in September 1975 and is currently undergoing Federal agency review.

Nuclear Power Export Activities

On August 1, 1975, ERDA issued the DEIS for the Nuclear Power Export Activities (ERDA-1542) for comment. The intent of the statement was to support the Nation's program of exporting nuclear power technology and to provide a basis for informed judgments on the nature, scope and direction of the U.S. nuclear export activities. The statement addressed activities associated with the export of commercial nuclear steam supply systems and related components, and of source and special nuclear material for commercial use in foreign power reactors. It covered the impacts on the U.S. and the high seas from possible diversion, theft or sabotage abroad of U.S. supplied materials or facilities.

In its comments, EPA concluded that the environmental impacts had not been adequately evaluated. The major concerns related to (1) failure to consider the impacts of reprocessing spent reactor fuel, (2) failure to consider impacts of radioactive gaseous discharges from the reactor or reprocessing plants, and (3) failure to assess the impacts of waste disposal resulting from fuel reprocessing plants. The evaluation of the world-wide population dose commitments from the impact of the release of radioactivity at mines and mills, reprocessing plants and the reactors was considered inadequate. Another significant concern was the lack of consideration of alternatives available for controlling the safeguards aspects, including denial of export approval unless the recipient was a party to the Non-Proliferation Treaty.

Waste Management Operations at the Hanford Reservation (WASH-1538)

The DEIS which was issued in September 1974 by the AEC was reviewed and comments transmitted by EPA in January 1975. In its review, EPA attempted to determine whether the information provided was complete and adequate to support the conclusion reached in the draft statement. In addition, EPA tried to evaluate whether the current monitoring program is adequate to determine if contamination is presently reaching the environment (and if so, in what quantities), and if the monitoring program has the capability to predict the present and future impact of the wastes on the environment.

It is EPA's opinion that the hydrogeologic information presently available is not sufficient to permit a comprehensive envaluation to be made of the potential for environmental damage represented by the presently stored waste, either on a short- or long-term basis. To remedy this situation, EPA recommended that an independent comprehensive re-evaluation be made of the hydrogeology of the Hanford site.

EPA's principal conclusions relative to the adequacy of the Hanford Reservation waste management operations were that there was a need for more hydrogeological information; a need to eventually eliminate reliance on soils to remove radioactivity from liquid wastes discharged to the ground; and a need to place more emphasis on determining an acceptable ultimate disposal form and method for the high-level wastes.

In December 1975, ERDA issued a final environmental statement on the Hanford waste management operations. The FEIS is currently undergoing Federal agency review.

Liquid Metal Fast Breeder Reactor (LMFBR)

The Atomic Energy Commission (AEC) issued a Proposed Final EIS (PFEIS) on the LMFBR (WASH-1535) for comment in December 1974, and ERDA came into existence in January 1975. The PFEIS was thus technically an AEC document, and as such was not adopted as an ERDA statement until ERDA completed its review of it. In December 1975, ERDA issued its FEIS on the LMFBR as an attachment to the AEC's PFEIS, and generally adopted the PFEIS as its own PFEIS. The purposes of this EIS were to continue the LMFBR research and development (R&D) program and to support the eventual commercialization of the LMFBR. However, as a consequence of the review of the PFEIS by EPA, ERDA and other parties, the Administrator of ERDA concluded in the FEIS that there were several areas of information which were not sufficiently well developed to enable prediction of impacts of commercialization. However, a commitment was made to fully re-evaluate the environmental impacts of LMFBR commercial deployment prior to commencement of construction of the first commercial plant. He further indicated that R&D, underway or planned, was expected to provide answers to important unresolved questions prior to the re-evaluation.

The major areas of concern relative to the LMFBR are (1) safety, (2) plutonium safeguards, (3) waste disposal, (4) transportation, and (5) the economic and resource justification for the LMFBR. The first four items are not unique to the LMFBR, but the problems are intensified by the LMFBR design. Each of these areas is expected to have vastly greater information available, much of which is dependent on a successful R&D program, before the re-evaluation is conducted.

In its comments on the PFEIS, EPA concluded that the environmental impacts of the LMFBR had been assessed about as well as is possible, given the state of the available information. Thus, in view of the unknowns associated with reactor safety, plutonium safeguards, waste disposal, and transportation safety, it is not possible to accurately predict the enviornmental impacts of a commercial LMFBR industry. EPA did not, however, identify any unresolveable problems which would preclude LMFBR commercialization. Further for a limited number of demonstration facilities, EPA concluded that an adequate level of safety could be provided through conservative design and siting criteria.

EPA further indicated that a decision to commercialize the LMFBR should be made after thorough evaluation of information generated in the ongoing and planned R&D. Similarly, the cost/benefit analyses should be re-evaluated in the future when more accurate and up-to-date data are available.

The commitments made by ERDA in their FEIS substantially resolved the concerns EPA had expressed about proceeding with the LMFBR program. In particular, the commitment to re-evaluate the environmental impacts and to publish a new environmental statement prior to construction of the first commercial LMFBR was a firm, positive step which will facilitate necessary consideration of the environmental impacts in the decision making process.

REFERENCES

1. Rowe, W.D., F.L. Galpin, and H.T. Peterson, Jr. EPA's environmental radiation assessment program. Nuclear Safety, Vol. 16, No. 6 (November 1975).

2. U.S. Environmental Protection Agency, *Radiological Quality of the Environment*, Office of Radiation Programs, EPA-520/1-76-010 (in press).

3. U.S. Environmental Protection Agency. *Environmental Radiation Surveillance Guide*, ORP/SID 72-2. Office of Radiation Programs, Washington, D.C. (June 1972).

4. Martin, J.A., C.B. Nelson, and P.A. Cuny. *AIREM Program Manual*: a computer code for calculating doses, population doses and ground depositions due to atmospheric emissions of radionuclides, EPA-520/1-74-004. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C. (May 1974).

5. U.S. Environmental Protection Agency, Radioactivity standards distribution program-1975, EPA-680/4-75-002a. Office of Research and Development, Washington, D.C. (April 1975).

6. U.S. Environmental Protection Agency, Environmental radioactivity laboratory intercomparison studies program-1975, EPA-680/4-75-002b. Office of Research and Development, Washington, D.C. (May 1975).

7. General Services Administration, Federal Preparedness Agency, "Radiological Incident Emergency Response Planning-Fixed Facilities and Transportation," *Federal Register*, Vol. 40, number 248 (December 24, 1975).

8. U.S. Environmental Protection Agency, *Approaches to Population Protection in the Case of Nuclear Accidents*, Office of Radiation Programs, (draft November 1974).

9. U.S. Environmental Protection Agency, *Emergency Response Protective Action Guides Airborne Releases from Fixed Nuclear Facilities*, Office of Radiation Programs, (draft January 1975).

10. U.S. Environmental Protection Agency, *The Comparative Risk Perspective for Setting Protective Action Guides*, Office of Radiation Programs, (draft January 1975).

11. U.S. Environmental Protection Agency, *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, Office of Radiation Programs document EPA-520/1-75-001.

NONIONIZING RADIATION – CHAPTER 7

INTRODUCTION

Electromagnetic radiation at frequencies below 10^{16} Hertz (Hz) is commonly called nonionizing radiation. As the term implies, "nonionizing" radiation does not produce ionization when it is absorbed. For practical purposes, the nonionizing part of the electromagnetic spectrum includes the ultraviolet, visible, infrared, radiogrequency, and extremely low frequency regions including power distribution frequencies at 50 and 60 Hz. Sources of interest include lasers, radars, radio and television broadcast stations, industrial heating equipment, microwave ovens, line of sight communciations including satellites, mobile communications systems, navigational aids, medical diathermy devices and others.

Because of the increase in the number and power of sources in the radiofrequency range since 1940, recent interest has focused on the effects produced by electromagnetic radiation at frequencies below 300 GHz (300×10^9 Hz) or equivalently with photon energies less than 1.24×10^{-3} electron volts. In this frequency range effects are associated with power density as follows: (a) exposures above 10 mW/cm^2 (high level) where thermal effects predominate, (b) exposures below 1 mW/cm^2 where thermal effects are improbable, and (c) exposures between 1 and 10 mW/cm^2 where the mechanism, thermal or nonthermal, is not established. (Figure 7.1)

The Environmental Protection Agency (EPA) and other Federal departments and agencies such as Health Education and Welfare, (HEW), Department of Defense (DOD), the National Bureau of Standards (NBS), and Department of Labor have program activities concerned with various forms of radiation consistent with their individual missions and responsibilities. Federal Government activities to assess the effects of radiowaves (0–3000GHz) are coordinated by the Office of Telecommunications Policy. Some States and non-Governmental organizations also have programs or activities in nonionizing radiation. This chapter summarizes the programs and activities of several agencies.

FEDERAL PROGRAMS IN NONIONIZING ELECTROMAGNETIC RADIATION (RADIOWAVES)

Federal Government activities concerned with biological effects of nonionizing electromagnetic radiation in the radiowave range (0–3000GHz) as are associated with telecommunications, are overviewed and coordinated by the Office of Telecommunications Policy (OTP) in the Executive Office of the President.

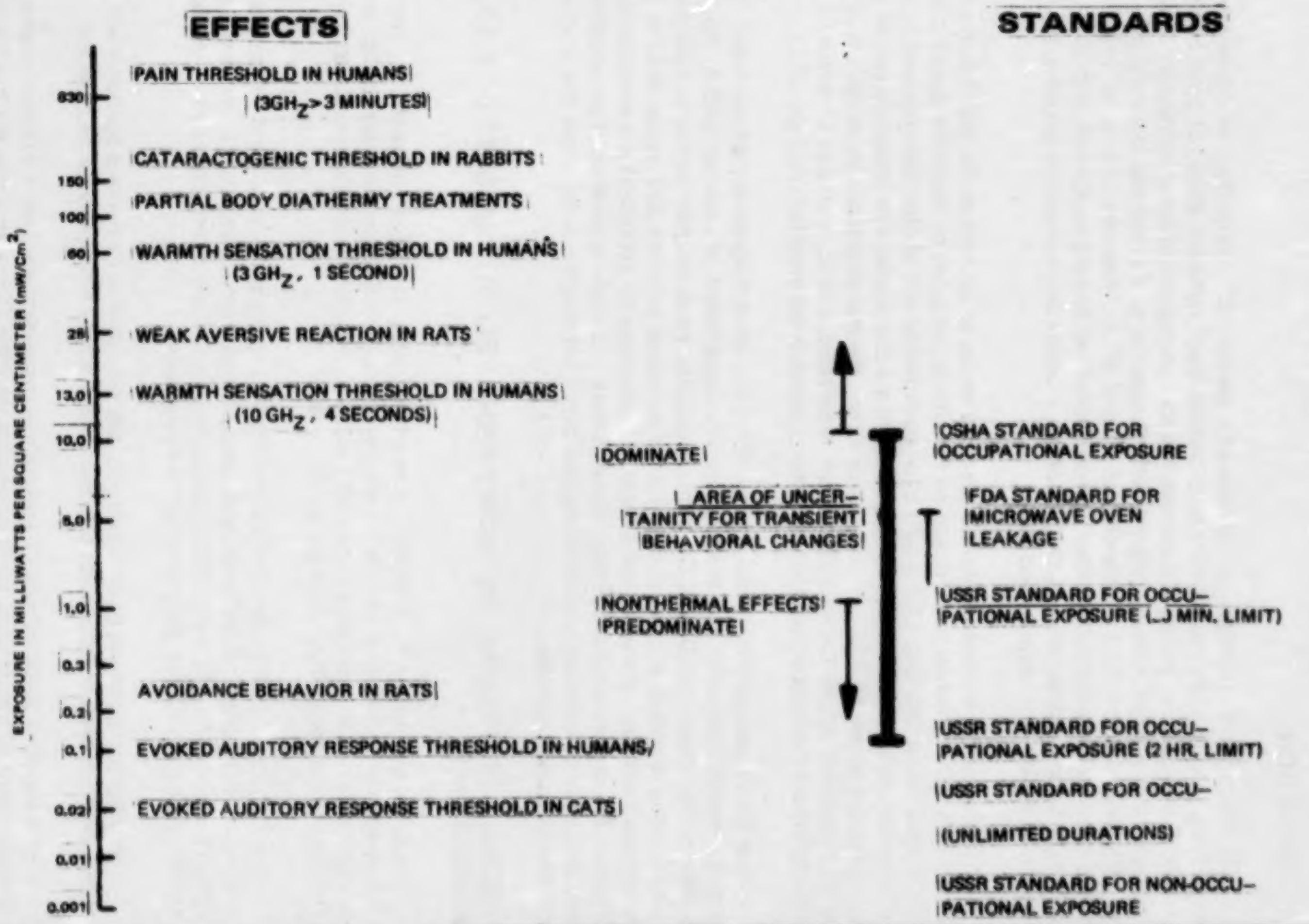
The purpose of this cooperative multiagency program which involves environmental measurements, testing, and research, is to assess the biological effects of these radiations and to develop a sound scientific basis for ensuring the compatibility of society's use of the spectrum with the health and well being of man and his environment.

This program is comprised of individually funded activities by Federal agencies with various responsibilities related to their basic missions. These include EPA, HEW, DOD, NBS, etc.

OTP's statutory responsibility for spectrum management involves the review, management, and assignment of frequencies for Government use; the Office also advises the President on

Figure 7.1

NONIONIZING RADIATION



national telecommunications policy. In this regard, OTP is concerned with any possible adverse "side effects" which might be associated with the use of the spectrum.

The Electromagnetic Radiation Management Advisory Council (ERMAC), established in 1968, assists OTP, providing advice and recommendations on possible side effects of electromagnetic radiations associated with the use of communication/electronics. Following a two year review of biological effects and Government activities, the ERMAC recommended a coordinated Federal program of nonionizing radiation effects research and environmental measurement (1). In early 1972 the current program was coordinated by OTP within the Government for implementation.

An interagency "Side Effects" Working Group was established within the Technical Subcommittee of the Inderdepartment Radio Advisory Committee. The principal function of this group is to provide for coordination of research and measurements programs. It also provides a forum for the exchange of information for agencies with ongoing research and other concerned agencies. About 20 different Government agencies are represented.

During 1975, OTP/ERMAC hosted workshop/seminars on "Measurements of Environmental Levels of Nonionizing Electromagnetic Radiation" (2) and on "Genetic, Hereditary, Growth and/or Developmental Effects of Nonionizing Electromagnetic Radiation" (3). The Side Effects Working Group met bimonthly throughout the year. Its activities include developing information on ongoing research programs and examining problems and related issues of mutual interest.

Each year OTP issues an annual report on the Federal Government's program to assess biological effects of nonionizing electromagnetic radiation (4,5). These annual reports summarize research efforts, give short descriptions of participating agencies programs and associated publications, and cover related issues and problems. The fourth annual report covering calendar year 1975 is being prepared and will be available in the spring of 1976.

Environmental Protection Agency

The nonionizing radiation activities in the Environmental Protection Agency are divided between two offices, the Office of Radiation Programs and the Office of Research and Development. Standards development, environmental measurements, and environmental evaluation are conducted by the Office of Radiation Programs. Biological effects research is conducted by the Health Effects Research Laboratory, Research Triangle Park, NC, a part of the Office of Research and Development. Environmental exposure data are collected, evaluated, and compared to known effects and research results to assess needs for criteria, guidelines, or standards to control exposure.

Environmental Nonionizing Measurements

The environmental nonionizing radiation program includes measurement of the general ambient environment and calculation, measurement, and evaluation of specific types of sources. The calibration and field testing of a mobile radiofrequency measurements system were completed in 1975. Data on ambient environmental levels in urban areas were collected. Evaluations were also made of several problems related to specific sources or source types.

Ambient Environment Studies

Using the mobile radiofrequency measurements system environmental levels of nonionizing radiation in Boston, MA (October 1975) and Atlanta, GA (December 1975) were measured. The data are being studied and population exposure is being computed on the basis of a population locator code (6). Figure 7.2 shows the van used in making electromagnetic radiation analyses. The interior of this van appears in Figure 7.3.

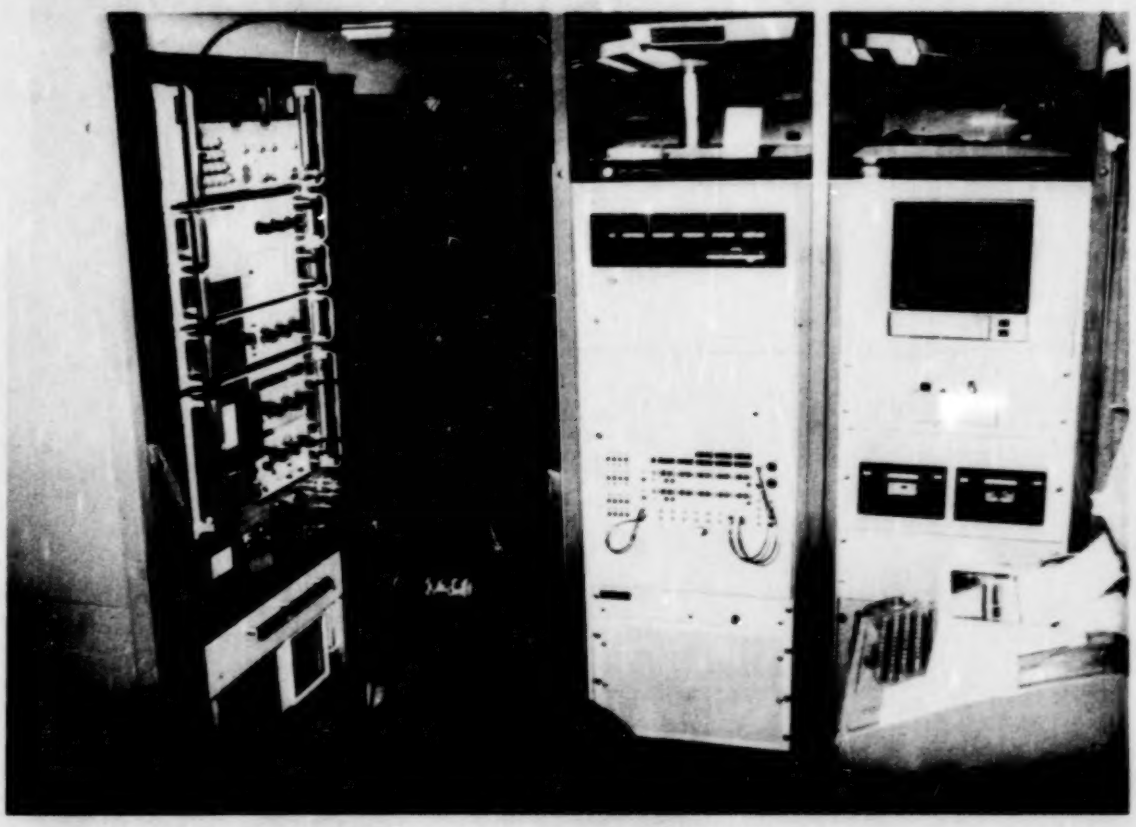
The measurements system uses a spectrum analyzer interfaced to a minicomputer for data acquisition and is housed within a 27-foot van equipped with its own electrical power supply. Special antenna systems allow isotropic field intensity measurements in selected bands between 0.5 MHz and 10 GHz. Data are collected for the standard AM broadcast band, the VHF-TV and FM bands, the 150 and 450 MHz land mobile bands and the UHF-TV band. Emphasis has been given to accurate system calibration. The antennas have been calibrated relative to NBS standard dipoles in a low background radiofrequency area (Green Bank, WV in June 1975). At the facilities of the Institute for Telecommunications Sciences in Boulder, CO (August 1975), radiation patterns have been determined for the antennas mounted on the van. The calibration and correction factors are stored in the computer and computer programs have been developed for different data collection modes which include peak signal strength retention and signal averaging (7,8).

Specific Source Studies

In February 1975, EPA was asked to assist a local health department evaluate the radiofrequency susceptibility of an electronic, digital readout, thermometer commonly used in hospitals. Through field tests and measurements it was determined that the thermometer was susceptible to radiofrequency interference at frequencies in the FM band (88–108 MHz). The interference resulted in erroneously high temperature readings. Interference was readily demonstrated at electric field strength levels of 1.5 Volts/meter (V/m). Maximum measured field strengths in the hospital from two nearby FM stations were 1.55 V/m (vertical polarization) at 105.1 MHz and 0.813 V/m (horizontal polarization) at 90.9 MHz. This interference problem was brought to the attention of the thermometer manufacturer and the Bureau of Medical Devices and Diagnostic Products in the Food and Drug Administration. As a result of this study the manufacturer changed the design of the thermometer and replaced the susceptible thermometers in the hospital.

In June 1975, at the request of the State of Hawaii, EPA evaluated the environmental impact of broadcast radiation levels on the island of Oahu. This request stemmed from the denial of a rezoning application to allow construction of a residential-commercial high-rise building within 50 feet of an existing FM-TV broadcast antenna tower. The fields in the vicinity of other broadcast towers were then questioned and the Hawaiian State Senate issued a resolution directing the Hawaiian State Health Department to study the problem and make a report to the State Senate. Based on source parameters, source location, and conservative propagation models calculations were made of the environmental radiofrequency levels from broadcast stations. The source distributions, parameters, and calculational models have been described (9). These conservative calculations indicated that there were no exposures exceeding 10 mW/cm^2, which is the OSHA standard for occupational exposure (10).

In September 1975, an analytical study was started on broadcast radiation levels at Mt. Wilson, CA. Based on the results of the analytical study, a field study to measure the levels of broadcast radiation was conducted during November 1975, in cooperation with the County of Los Angeles Department of Health Services. In close proximity on Mr. Wilson are a number of



broadcast antenna towers on which are mounted the antennas for 27 FM and TV stations which serve the Los Angeles metropolitan area. Of particular interest were the environmental levels in the vicinity of the Mt. Wilson Post Office which also serves as the residence of the Postmaster. The Post Office is located within several hundred feet of a number of the antenna towers. Calculations using the usual conservative assumptions indicated that ground level exposure values would be in the range from 1 to 44 mW/cm^2. The maximum measured value found in the vicinity of the Post Office in the field study was 4.8 mW/cm^2 at a single location. More typical values fell in the range from 0.2 to 2 mW/cm^2 outside the Post Office building and 0.06 to 0.6 mW/cm^2 inside. A detailed description of the field study is being prepared (11). During the field study, measurements were obtained of the fields which exist on an FM antenna tower and to which station or maintenance personnel might be exposed when working on the tower. Levels well in excess of the OSHA standard (10) were found.

A summary (12) of earlier work on radiation levels from specific sources and measurements of the general ambient radiofrequency environment was presented to the Electromagnetic Radiation Management Advisory Council (ERMAC) in April 1975. The ERMAC is an advisory group to the Office of Telecommunications Policy on possible "side effects" associated with the use of the spectrum; references to earlier work performed by EPA are listed in the annual reports of the Office of Telecommunications Policy (13,14).

High Voltage Transmission Lines

Private citizens, public interest groups, and State agencies have expressed concern about the potential adverse effects that may be associated with the transmission of electric power at extra-high voltages (EHV), i.e., voltages at or above 345 kilovolts (kV).

In part, because of these concerns, the Environmental Protection Agency published a notice in the *Federal Register* in March 1975, requesting data and information on the health and environmental effects of EHV power transmission (15). Over 50 replies totaling over 6,000 pages were received from the following groups: electric utility or organization, 14; Federal agency, 8; citizen or citizens' group, 6; State agencies, 5; consulting firms, 4; equipment manufacturer, 4; city or county planning agency, 3; university, 3; railroad, pipeline, and professional society, 1 each. A preliminary analysis of the submitted information and of information from other sources has not identified any acute detrimental health or environmental effects (16). Further work to determine any potential subtle problems and to determine if areas of concern have been adequately investigated will be carried out under contract.

Representatives of EPA have participated in a number of meetings and working groups which are investigating EHV problems. In April 1975, as part of an Electric Power Research Institute (EPRI) sponsored contract, the Illinois Institute of Technology Research Institute (IITRI) hosted a workshop on 60 Hz electric field effects on life forms. A summary of the workshop activities and a critical review of effects literature has been published (17) together with an annotated effects bibliography (18). In October 1975, IITRI hosted another workshop sponsored by the Energy Research and Development Administration on electromagnetic coupling and corona effects. A report is to be published in the near future.

EPA is participating in the deliberations of the "Task Force on the Technical Basis for Selection of Interference Limits from Electric Power Lines and Stations," which is part of the Radio Noise and Corona Subcommittee of the IEEE Power Engineering Society. EPA representatives participated in the IEEE sponsored field day at Project UHV in Pittsfield, MA. Experience was gained in calibrating and using electric and magnetic field measuring equipment.

The program participants also obtained data on electric shock perception and annoyance thresholds. EPA is participating in an Interagency Advisory Committee on Electric Field Effects from High Voltage Lines, which is chaired by ERDA. The committee's objective is to coordinate all Federally sponsored research efforts relating to the environmental effects of electric fields from high voltage transmission lines.

Biological Effects Research

The nonionizing radiation biological effects program has broadened and taken new direction in 1975. A wide range of biological experiments is being conducted with rapidly improving dosimetry. New equipment both for locating likely frequencies of interaction and for laboratory exposure systems is being developed and put into use. The results of recent work have been published (22–38) and current work is summarized below.

A major objective in the dosimetry work is to report all exposures in terms of energy absorption or rate of energy absorption by the biological system. Methodology has been developed to measure and analyze cooling curves for *in vitro* systems from which energy absorption rates are calculated. Twin well calorimeters are being constructed so that whole body absorbed dosage can be measured for small animals up to the size of large rats. In addition, the use of transmission line exposure geometries allows absorbed power to be calculated from measured values of forward, reflected and transmitted power.

Other dosimetry work is also in progress. Computer software has been developed so that thermographic camera pictures of dose distribution in animals may be analyzed quantitatively. Field perturbations caused by neighboring animals in a multi-animal exposure have been investigated and various configurations of animal placement have been tried in order to minimize such scattering. An X-band field probe has been constructed using a Schottky diode detector and microwave transparent semiconductor leads. This probe is being used to measure field intensities in the X-band exposure chamber from 1 W/cm^2 to 10 mW/cm^2 (average power, pulsed) for frequencies between 8.5 and 9.6 GHz. Mathematical modeling in order to estimate exposure and dose is continuing.

Several biochemical and cellular level investigations have been pursued. The binding of pseudosubstrates to the enzyme ribonuclease while undergoing irradiation has been investigated using the crossed-beam apparatus for simultaneous irradiation and observation. No differences between samples irradiated at 1.7 and 2.45 GHz to exposure rates of 40 W/kg and unirradiated samples were found. Mitochondrial suspensions were exposed in a system that continually circulates the sample through a coaxial airline and an oxygen electrode cell. Exposures were at 2.45, 3.0 and 3.4 GHz (41 W/kg) while the mitochondria were biochemically active and respiration was measured as the sample flowed from the airline. No differences in respiration or oxidative phosphorylation were found between irradiated and control mitochondria. Swept frequency measurements between 2.0 and 4.0 GHz (at about 2 W/kg) were also made using this system. Again no differences were found.

The effects of nonionizing radiation on immune defense systems is under investigation. The phagocytic activity of guinea pig neutrophils during irradiation at 2.45 GHz was assayed biochemically. No change in phagocytosis was noted. In a related study, the phagocytic activity of rat peritoneal macrophages during irradiation at 2.45 GHz is being investigated. Preliminary results again indicate no change. Both experiments were inspired by the report of Mayers and Habeshaw (Int. J. Rad. Biol. 24: 449–461, 1973) indicating a change in phagocytic activity of irradiated macrophages.

Mouse splenic lymphocytes have been irradiated *in vitro* at 2.45 GHz and their capacity to undergo DNA synthesis after stimulation with several mitogens has been measured. No differences in the response of irradiated and control lymphocytes was found. Live mice are being irradiated at 2.45 GHz. Peripheral blood and splenic lymphocytes from these animals are being assayed for their ability to undergo blast transformation and for DNA synthesis in the presence and absence of specific mitogens. This work is in progress. Mice are also being immunized before exposure to 2.45 GHz CW and 9.0 GHz pulsed radiation and subsequently checked for antibody titer. This work is also in progress.

Genetic effects work is being largely conducted extramurally with exposures made in EPA facilities. The results of the completed study on Drosophila were presented at an OTP/ERMAC seminar. *Saccharomyces cerevisiae* and *Salmonella typhimurium* have been irradiated at 8.5–9.6 GHz (pulsed) and are being examined for alteration in mutation rate and secondary cellular effect. Chinese hamsters are being irradiated at 2.45 GHz and 9.0 GHz pulsed between 5 and 45 mW/cm^2. Peripheral blood lymphocytes are being cultured and examined for chromosome aberrations. So far none have been found, but secondary studies indicate that irradiated lymphocytes undergo blast transformation but then do not divide even after stimulation with a mitogen. Such a result, if confirmed, would indicate a serious decrease in the ability of the lymphocyte system to respond to antigenic stresses. Work is continuing to elucidate this effect.

Teratological studies are being conducted on mice and rats. In the major study so far pregnant female mice were irradiated 100 min. daily at 14 and 28 mW/cm^2 in a 2.45 GHz free field exposure. Eighteen days after breeding the fetuses were examined. The weights of animals in the higher dose group were significantly lower than the weights of the control animals. A nonsignificant incidence in encephaloceles was noted in both exposed groups. However, the incidence was significant when the data from both exposed groups was combined and compared to controls. Adult male rats irradiated at 2.45 GHz periodically for 4 weeks at 28 mW/cm^2 showed a 50% loss in capacity to impregnate when breeding was conducted immediately after the final irradiation. Work is continuing in this area.

Behavior of rats after exposure to microwave radiation is being studied. In one study, male rats were irradiated 4 hours daily from birth to 21 days at 9 Ghz (pulsed) in fields of 3 to 10 mW/cm^2 average power. The rats were tested for signs of changes in growth, reflex development, activity and development of operant behavior. No significant difference from controls was found. In a second study, male rats were exposed to 2.45 GHz at 10 mW/cm^2, 15 hours/day, 3 times weekly for 3 or 6 months. Measurement of a previously acquired operant performance was made over the course of the exposures. No difference from controls attributable to microwave exposure was found. These same rats were then exposed to 12.5 to 20 mW/cm2 for 15 hours at a time. Preliminary data indicate lower rates of operant behavior for exposures at 12.5 mW/cm^2 and above.

New instrumentation has been developed for exposure of samples *in vitro* and small animals. These are essentially coaxial transmission lines of rectangular cross section (known as Crawford cells). Exposures in a small Crawford cell can be made at frequencies between 500 and 1100 MHz. Amplitude modulation of the RF source for this cell is available using a pin diode and a low frequency function generator. One instrument is being tested and will be used in cellular genetic and membrane studies. A large Crawford cell which propagates 100–450 MHz has been constructed for use in experiments including irradiation of rats or mice, investigation of absorption characteristics of small animals, and other experiments involving amplitude modulated fields. A temperature control system has been developed for use with the Crawford cells. It regulates temperature to 0.1° C from 15° to 45° C.

Other instrumentation is being developed for measuring absorption frequencies of *in vitro* biological samples. A double line microwave spectrometer will compare directly the power absorption of an unknown sample against a reference. Frequency will be scanned from 250–4000 MHz. The development of a time domain reflectometer (TDR) is continuing. It will allow the determination of the complex dielectric constant of biological materials for a frequency range up to 9 GHz.

Bureau of Radiological Health

The Bureau of Radiological Health (BRH) of DHEW conducted several programs to help determine future performance criteria. The effort dealt with the calibration at 2450 MHz of microwave radiation measurement instruments and the completion and operation of a new high performance microwave power density calibration facility in the Division of Electronic Products. The facility has the capability to make accurate microwave measurements at many frequencies. Studies are made of electronic products emitting in radiofrequency, VHF, UHF and microwave regions of the electromagnetic spectrum and devices for their control in support of enforcement, standards development, and product testing.

Microwave Ovens

In 1975, 69 production or pre-production microwave ovens have been laboratory tested and found to be in compliance with the Federal Performance Standard for Microwave Ovens. Compliance actions were taken against five manufacturers of microwave ovens.

During May 1975, the FDA's Bureau of Radiological Health notified a manufacturer of microwave ovens that more than 18,000 ovens were found to be a potential radiation hazard, since they were capable of emitting up to 10 times the maximum limits allowable by the Federal standard for radiation emission.

A total of 1,814 certified microwave ovens were inspected by field personnel and an additional 482 uncertified ovens were inspected. Field personnel reviewed the records of 405 dealer or distributors of microwave ovens, in order to determine that these records were sufficient to permit the tracing of specific ovens to specific purchasers.

BRH has proposed an amended performance standard for the requirements for interlock concealment and prevention of object insertion into microwave ovens. The proposal appeared in the *Federal Register* on June 26, 1975.

The proposal requires that concealed interlocks must meet the commonly accepted definition of concealment—that is, the interlock must be hidden from view. The amendment would allow ovens to have, as an alternative to a concealed interlock, an interlock that cannot be actuated when access to it is possible. In addition, the requirement concerning insertion of objects into the oven would be changed to provide a better definition of "object" and to prohibit insertion of these objects into the cavity, waveguide, and other oven spaces that contain microwave energy.

The present standard requires that the concealed interlock not be operable by any part of the human body or by a rod 3 millimeters in diameter and 10 centimeters in useful length. Some oven manufacturers in the past have met the nonoperability conditions of this requirement even though the interlock was not "concealed" but was visible to the user and could be defeated by common household objects. The proposed amendment would solve this problem by clarifying that the nonoperability tests are not to be equated with the concept of concealment, but are additional requirements that must be met. It also would delete the diameter specification for the rod to allow the test object to simulate items commonly found in homes, and would require that any visible interlock actuator or device which prevents actuation of an interlock not be removable without disassembly of the door. The proposed requirements would apply to ovens manufactured on or after 1 year from the date on which the amendment is published as a final rule.

According to the preamble in the *Federal Register*, the proposal to amend the standard at this time should not be interpreted as indicating that ovens presently available are unsafe. Most manufacturers have, in the past, correctly interpreted the intent of the standard and have manufactured microwave ovens that would fully meet the requirements of the proposed amendment or, when misunderstandings have occurred, have voluntarily corrected the designs to comply with the intent of the standard.

Microwave Exposure Levels from Marine Radar Evaluated

BRH has conducted a study of the range and magnitude of microwave radiation exposure associated with marine radar units used on small pleasure boats. The project included a survey of 33 marine radar units in actual use, a compilation of information concerning 43 different marine radar models, laboratory measurements in the Division's anechoic chamber, and a comparison of calculated emission levels with experimentally measured values.

According to a recently published report on the study, personnel exposure to microwave emissions from the radar units probably will not exceed 1 mW/cm^2 average power density under normal operating conditions. However, significantly increased emission levels might be encountered if a unit is operated with the antenna rotation stopped. The report recommends that exposure under such conditions be avoided.

Another finding was that instantaneous peak microwave emissions in the region surrounding the antenna might be quite high. Although any possible biological hazards associated with these emission levels are uncertain at present, the possibility of interference phenomena in critical devices, such as cardiac pacemakers, seems to warrant caution. Therefore, the report suggests that care be exercised to limit the unnecessary use of marine radar in areas of high population density—for example, when docked in harbors.

The U.S. Coast Guard has agreed to a program of cooperation with BRH on the safety aspects of marine radar.

Radiofrequency and Microwave Products and Devices

Microwave Diathermy Survey – A limited microwave diathermy field survey conducted by BRH found that: (a) although diathermy users are aware of possible harmful effects from microwave exposure, their understanding is limited, and (b) equipment manufacturers do not supply users with sufficient information on the radiation emission pattern from the diathermy applicator, so that some treatments may expose a larger body area than prescribed. The survey was part of a fact-gathering mission to determine the need for a Federal performance standard for microwave diathermy equipment. It focused primarily on equipment use, but also considered treatment techniques and machine performance characteristics.

The need for a microwave diathermy equipment standard was brought to the attention of the Technical Electronic Products Radiation Safety Standards Committee (TEPRSSC) by BRH during the committee's meeting in September 1974. Microwave diathermy is a procedure in which heat is induced in the tissues beneath the skin by microwaves. Because excessive microwave radiation may be harmful, precautions should be taken to assure safe equipment performance.

Information and comments on the following topics are specifically invited by BRH:

(a) The types of radiation safety performance requirements which would be appropriate for microwave diathermy equipment; for example, emission level requirements, interlocks, indication of output power, means of beam limitation or definition, and so forth.

(b) Appropriate emission levels from the entire unit, including the applicator, and the methods and conditions of measurement.

(c) Appropriate radiation safety warning labels and user and service instructions.

(d) The possible environmental impact of this action, including factors such as radiation exposure reduction and economic consequences in relation to expected benefits (cost-benefit relationship).

RF and Microwave Energy Deposition in Humans – BRH's Division of Electronic Products is developing new mathematical techniques and computer programs for predicting the geometrical distributions of dissipated radiofrequency and microwave energy within complex systems such as the human body. This project is aimed at providing accurate estimates of energy deposited in humans exposed to emissions from such devices as microwave, diathermy, short-wave, and radar equipment.

When nonionizing electromagnetic radiation interacts with biological systems, the potential for harm results from the electromagnetic fields induced within the irradiated tissues. In some instances, these fields or the subsequent tissue heating may be determined experimentally by using implantable probes in living tissue or infrared sensors in phantom (biologically simulated) material. These techniques, however, have many practical drawbacks.

In an alternate approach, DEP is mathematically simulating the interaction of an electromagnetic field with a region of space having electrical properties and geometric structure representative of a living organism. Computer-assisted calculations then determine the distribution of energy throughout the region. This mathematical problem, although quite formidable, has been solved for simple geometries such as spheres, planes, and infinite cylinders. Recently, the energy distribution within a multilayered spherical model of a human head exposed to microwave radiation has been calculated.

The next step in the project will be development of the more complex mathematical models needed to predict the energy distribution in irregularly shaped areas of the body.

Occupational Exposure to Radar – BRH is assessing the association of microwave radiation (radar) with the health of naval personnel by relating occupational differences in levels of exposure to subsequent mortality in the veteran period, hospitalized illness at the time of occupational exposure, and later disability. The study is being done under contract with the National Research Council by means of search, linkage, and analysis of the records of a sufficiently large maximally exposed group and a comparable minimally or nonexposed group of Korean War veterans.

Light Products and Devices

Testing of Laser Eyewear – The U.S. Air Force School of Aerospace Medicine is to test some 20 types of commercially available protective eyewear used by persons working with lasers to evaluate their long-term effectiveness and reliability. The work, an extension of ongoing testing of laser eyewear procured by the Defense Department, is being carried out under an interagency agreement between BRH and the Air Force.

BRH teamed up with the Air Force testing program to supplement its efforts in evaluating laser eyewear. A limited investigation in BRH laboratories has found that some types of eyewear fail after several seconds of exposure to laser beams of about one watt—a level at which users (might) expect protection. The Bureau initiated the tests based on reports that the lenses of some eye protection devices deteriorate due to environmental conditions and others fail to meet designed optical densities—a measure of the fraction of radiation transmitted through the lens.

Protective eyewear, including goggles, glasses, and face guards, is used in certain industrial, medical, and research applications to safeguard operators or bystanders from high levels of laser radiation which could cause serious eye damage. Although there have been no reports of human injury resulting from lens failure, the possibility of accidental eye injury exists.

BRH will use data obtained under the agreement to determine methods by which eyewear can be uniformly tested by manufacturers for protection effectiveness and labeled with essential user information. For the most part, eyewear being produced today lacks any indication on the product or container as to the upper exposure limit for which protection is guaranteed and lacks wavelength information to indicate its correct application.

According to the agreement, the School of Aerospace Medicine will perform optical and physical quality tests for each type eyewear. Optical tests are designed to evaluate optical distortion and spectral transmission characteristics of the lens material. The physical quality tests are to include (1) determination of the optical density under laser illumination, (2) exposure of lens and frame materials to increasing amounts of laser radiation until irreversible damage occurs, for example, the material melts or explodes, (3) evaluation of bleaching effects in the lens, (4) checks on impact resistance, and (5) determination of the long-term stability of the eyewear.

Visible and Ultraviolet Radiation Products

During July 1974, a manufacturer of an ultraviolet dental appliance was notified that two defects relating to safety of use existed in the product. Corrections were being made to these products. However, FDA became aware of 31 unreported but alleged injuries resulting from use of the product. Investigations and review of the manufacturer's records revealed an additional defect and more alleged injuries. The manufacturer was notified in May 1975 and requested to correct all three defects. The alleged injuries are being reviewed to determine if there is medical substantiation for irradiation injuries.

At the request of BRH, a task group of the American National Standards Institute (ANSI) is developing a voluntary standard that will specify safety features to minimize the ultraviolet radiation hazards associated with the use of damaged mercury vapor discharge lamps. BRH is supporting the ANSI effort at the suggestion of the Technical Electronic Product Radiation Safety Standards Committee (TEPRSSC) that it cooperate with industry to develop a voluntary, industry-wide standard for these lamps. Realizing it could take a long while to develop a voluntary standard, TEPRSSC also advised BRH to proceed with a parallel effort to develop a regulatory standard that could be issued if it appeared that an effective voluntary standard would not be forthcoming within a reasonable period of time.

Laser Calorimeter System – The initial phase of an intercomparison of BRH's laser calorimeter with the National Bureau of Standards (NBS) system has demonstrated that the BRH's calibration system is in agreement with the NBS standard calorimeter at the power levels used. The NBS system is the primary national standard against which the validity of all optical radiation measurements are checked. The system is used to calibrate laser survey instruments that will be needed for making low-level, continuous-wave radiation measurements in the laboratory and the field.

Ultrasound Products and Devices

Visualization and Measurement of Ultrasonic Beams – A state-of-the-art system for visualizing and measuring certain output characteristics of ultrasound diagnostic devices is now operational in BRH's acoustics laboratory. Specifically, the ultrasonic system, known as ultrasonovision, can map out the distribution of an ultrasonic beam and measure its intensity. The division plans to use the system to (a) analyze beam patterns from various ultrasonic transducers, (b) evaluate transducer performance, and (c) check the total ultrasonic device as an integral unit.

Diagnostic Ultrasound Equipment Survey – BRH, in cooperation with the District of Columbia Bureau of Radiological Health, conducted a field survey of diagnostic ultrasound equipment in 1975.

As a result of this study, BRH found that the output from some newer pulse echo units to be, in some cases, less than a milliwatt. It was also found that the sensitivity of measurement equipment will have to be lower than previously anticipated. This indicates that satisfactory imaging can be obtained with current diagnostic equipment at relatively low power levels.

Feasibility Study of Possible Adverse Effects of Diagnostic Levels of Ultrasound on the Fetus – A feasibility study was initiated in 1975 to determine whether a full-scale study of the possible delayed effects of ultrasound on the fetus can be made, using the records of obstetric examinations of 1967–69 as the starting point. Its purpose is to assess the adequacy of the original hospital records, success in tracing children, and the feasibility of including medical examinations. Reported biological effects of ultrasound at high levels in experimental animals include chromosomal anomalies, birth defects, cataracts,, tissue necrosis, hemorrhage, skin burns, and leg paralysis. At the levels used for diagnosis in humans, such serious manifestations have not been observed. Nevertheless, studies in humans are needed to confirm the absence of adverse effects.

STATE AND RELATED ACTIVITIES

Texas is developing regulations for the control of radiofrequency electromagnetic radiation (39). The November 1, 1975 draft is subject to further change and to approval by the Texas Radiation Advisory Board before adoption. The regulations would impose control measures on microwave ovens and on sources where accessible fields exceed the exposure limits promulgated by the American National Standards Institute (40). In addition microwave ovens used in commercial food vending services and sources which produce accessible radiation levels ten times the ANSI exposure limits must be registered. Sources licensed by the FCC and installations of the departments and agencies of the Government of the United States are exempt from the regulations.

The New York Public Service Commission is holding common hearings on two proposed 765 kV overhead electric transmission lines (41). Such issues as oxidant production, audible noise, induced electric shock currents, and cardiac pacemaker performance will be addressed during the hearings, expected to last through spring or summer of 1976.

MEETINGS AND PROGRAM RELATED ACTIVITIES

There is an increasing interest in combining thermal therapy with either chemotherapy or ionizing radiation therapy for the treatment of tumors. A workshop sponsored by the American Association for the Advancement of Science and the National Cancer Institute was held in April where the combination of heat and chemotherapy was discussed (19) and two papers were given at the International Microwave Symposium on the combination of heat and ionizing radiation therapy (20). The two principal meetings where significant work on the biological effects of nonionizing radiation were presented were the Microwave Power Symposium (20) and the United States National Committee of the International Union of Radio Science Annual Meeting (21).

The American National Standards C95 Committee on Radiofrequency Radiation Hazards held its 1975 meeting in conjunction with the USNC/URSI Meeting. There are seven active subcommittees. Subcommittee (IV), "Safety Levels and/or Tolerances with Respect to Personnel," is reorganizing so that it can address several issues prior to reissuing an exposure standard in 1979. There are now five working groups: 1. low level effects, 2. high frequency safety standards, 3. peak power safety standards, 4. population versus occupational exposure, and 5. literature review. The National Council on Radiation Protection's Scientific Committee SC-39 on Nonionizing Radiation is currently working on three reports: "Quantities and Units," "General Measurements," and "Biological Effects."

Under the US-USSR Health Agreement, joint and complimentary studies of nonionizing central nervous system and behavioral effects are planned. The exchange program is managed by the National Institute of Environmental Health Sciences and includes participation by the Bureau of Radiological Health and the Environmental Protection Agency.

REFERENCES

1. Electromagnetic Radiation Management Advisory Council (1971), "Program for control of electromagnetic pollution of the environment: the assessment of biological hazards of nonionizing electromagnetic radiation," Office of Telecommunications Policy, Washington, D.C.

2. Ibid (1975), "Summary of ERMAC work session on measurement of environmental levels of nonionizing electromagnetic radiation, "Office of Telecommunications Policy, Washington, D.C.

3. Ibid (1975), "Workshop on genetic, hereditary, growth and/or developmental effects of nonionizing electromagnetic radiation," Office of Telecommunications Policy, Washington, D.C.

4. Office of Telecommunications Policy (1974), "Second report on program for control of electromagnetic pollution of the environment: the assessment of biological hazards of nonionizing electromagnetic radiation, Washington, D.C.

5. Ibid (1975), "Third report on program for control of electromagnetic pollution of the environment: the assessment of biological hazards of nonionizing electromagnetic radiation, Washington, D.C.

6. Athey, T.W., R.A. Tell, and D.E. Janes (1974), "The use of an automated population exposure calculations," in *Population Exposures*, Proceedings of the Eighth Midyear Topical Symposium of the Health Physics Society, PP. 30–36, USAEC Technical Information Center (CONF-74 1018), Oak Ridge, TN.

7. Tell, R.A., N.N. Hankin, and D.E. Janes (1974), "An automated measurement system for determining environmental radiofrequency field intensities," in *Program and Abstracts, 1974 Annual Meeting, United States National Committee, International Union of Radio Science*, p. 28. National Academy of Sciences, Washington, D.C. (text available from authors).

8. Tell, R.A., N.N. Hankin, J.C. Nelson, TW.W Athey, and D.E. Janes (1976), "An automated measurement system for determining environmental radiofrequency field intensities, II," to be published in *Proceedings of the NBS 75th Anniversary Symposium, Measurements for the Safe Use of Radiation*, National Bureau of Standards, Gaithersburg, MD.

9. Tell, R.A. (1975), "An analysis of broadcast radiation levels in Hawaii," Technical Note ORP/EAD 75–1, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 10. Department of Labor, Occupational Safety and Health Administration (1974), "Nonionizing radiation," Title 29 Code of Federal Regulations, 1910.97.

11. Tell, R.A. and P.J. O'Brien (1976), "An investigation of broadcast radiation intensities at Mt. Wilson, California" (in preparation), Environmental Protection Agency, Washington, D.C.

12. Janes, D.E., N.N. Hankin, T.W. Athey, and R.A. Tell (1975), "EPA Nonionizing Radiation Measurements Program," in Summary of Electromagnetic Radiation Management Advisory Council (ERMAC) Work Session on Measurement of Environmental Levels of Nonionizing EM Radiation, Office of Telecommunications Policy, Washington, D.C.

13. Office of Telecommunications Policy (1974), "Second Report on 'Program for control of electromagnetic pollution of the environment: the assessment of biological hazards of nonionizing electromagnetic radiation," Washington, D.C.

14. Ibid (1975), "Third Report on 'Program for control of electromagnetic pollution of the environment: the assessment of biological hazards of nonionizing electromagnetic radiation," Washington, D.C.

15. Strelow, R. (1975), "Extremely high voltage transmission lines, health and environmental effects," *Federal Register* 40(53): 12312.

16. Janes, D.E. (1975), "Electric effects of extra-high voltage and ultra-high voltage transmission lines," Westinghouse International School for Environmental Management, Colorado State University.

17. Bridges, J.E. (1975), "Biological effects of high voltage electric fields: state-of-the-art review and program plan," Electric Power Research Institute, Palo Alto, CA.

18. Bridges, J.E. (1975), "Bibliography on biological effects of electric fields," Electric Power Research Institute, Palo Alto, CA.

19. Atkinson, R.E. (Chairman) (1975), "Microwaves as an adjunct to cancer treatment," Workshop sponsored by American Association for the Advancement of Science and the National Cancer Institute, National Institute of Health, Bethesda, MD.

20. Microwave Power Sumposium (1975), University of Waterloo, Waterloo, Ontario, Canada (Program) International Microwave Power Institute, Edmonton, Alberta, Canada.

21. U.S. National Committee International Union of Radio Science (1975), Abstracts, National Academy of Sciences, Washington, D.C.

22. Weil, C.M., "Absorption characteristics of multi-layered sphere models exposed to UHF-microwave radiation," IEEE Trans. Biomed. Eng. BME-222: 468–477 (1975).

23. Weil, C.M., "Absorption of microwaves in medicine," Presentation at Annual Meeting of NC Section IEEE, Winston-Salem, NC, Nov. 1975.

24. Allis, J.W., C.M. Weil, and D.E. Janes, "A crossed-beam apparatus for simultaneous spectrophotometric observation and microwave exposure of biochemical samples," Presentation at IEEE AP/S URSI Symposium, Urbana, IL, June 1975; Rev. Sci. Instrum. *46*: 1344–49 (1975).

25. Allis, J.W., "Irradiation of bovine serum albumin with a crossed-beam exposure-detection system," Ann. N.Y. Academy Sci. *247*: 312–322 (1975).

26. Blackman, C.F., S.G. Benane, C.M. Weil, and J.S. Ali, "Effects of nonionizing electromagnetic radiation on single-cell biologic systems," Ann. N.Y. Acad. Sci. 247: 352–366 (1975).

27. Elder, J.A. and J.S. Ali, "The effects of microwaves (2450 MHz) on isolated rat liver mitochondria," Ann, N.Y. Acad. Sci. *247*: 251–262 (1975).

28. Ward, T.R., J.W. Allis, and J.E. Elder, "Measure of enzymatic activity coincident with 2450 MHz microwave exposure," Presentation at IEEE AP/S URSI Symposium, Urbana, IL, June 1975; J. Microwave Power —: 315–320 (1975).

29. Allis, J.W. and M.L. Fromme, "Pseudosubstrate binding to ribonuclease during exposure to microwave radiation at 1.70 and 2.45 GHz," Presentation at Annual Meeting of USNC/URSI, Boulder, CO, October 1975.

30. Blackman, C.F., M.C. Surles, and S.G. Benane, "The effect of microwave exposure on bacteria," Ibid.

31. Elder, J.A., J.S. Ali, and M.D. Long, "Respiratory activity of mitochondria exposed in a coaxial airline to 2000–4000 MHz microwave radiation," Ibid.

32. Smialowixz, R.J. "The effect of microwaves (2450 MHz) on lymphocyte blast transformation in vitro," Ibid.

33. Elder, J.A., "Biological effects of nonionizing radiation," Presentation at the Second Joint U.S./U.S.S.R. Symposium on the Comprehensive Analysis of the Environment, Honolulu, Hawaii, October 1975.

34. Ali, J.S., "A versatile temperature controlled exposure chamber for microwave bioeffects research," IEEE Trans. Biomed. Eng. *BME-22*: 76–77 (1975).

35. Chen, T.F., "Heat absorption via electromagnetic fields in drosophila melanogaster," Doctoral dissertation, Univ. of Oklahoma, 1975.

36. Braver, G. (Univ. of Oklahoma), "Effects of electromagnetic fields of genetic phenomena," Presentation to OTP/ERMAC Side Effects Working Group, Washington, D.C., August 1975.

37. Berman, E., "Teratological effects of nonionizing electromagnetic radiation," Ibid.

38 Elder, J.A. and A.T. Huang, "Cytogenetic and immunological studies of microwave irradiated animals," Ibid.

39. Anon. (1975), "Texas regulations for the control of radio-frequency electromagnetic radiation," (Draft, November 1, 1975), Texas Department of Health Resources, Austin, TX.

40. American National Standards Institute (1974), "Safety level of electromagnetic radiation with respect of personnel, (ANSI C95,1–1974), Institute of Electrical and Electronics Engineers, New York, NY.

41. Rosenbaum, W.B. and R.E. Lee (1975), "Licensing of 765,000 volt ac power transmission lines in New York State: part a – present status," The Rochester Committee for Scientific Information Bulletin 186A, Rochester, NY 14627.

INTERNATIONAL ACTIVITIES OF INTEREST TO THE U.S. - CHAPTER 8

INTRODUCTION

From an international viewpoint there continues to be increased and extensive programs in nuclear safety and safeguards, waste management and control, and environmental research. In the area of nonionizing radiation, increased emphasis is being placed on gathering population exposure data, establishing internationally acceptable nominclature and stimulating research on the biological effects of nonionizing radiation. The continuing use of regional study groups, and the conduct of training courses and international symposia assists many countries in developing their nuclear power programs and providing the required environmental protection.

INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

In July 1975, the IAEA published its "Annual Report, 1 July 1974–30 June 1975," which provides information on the activities in radiation protection. The importance and scope of the work on nuclear safety and environmental protection continues to grow and to be concentrated increasingly on practical problems arising from the use of nuclear power. During the period under review, the IAEA has completed the general plan for a comprehensive set of safety codes and guides for nuclear power plants. The initial plan calls for five codes of practice and 12 safety guides. It has also continued to give high priority to the problems of storing and disposing of radioactive wastes and has formulated provisional definitions and recommendations regarding the disposal of such wastes at sea.

Three symposia were held on topical questions of nuclear safety; the IAEA began work on a research project regarding risk acceptance. The number of regional study groups and training courses and safety and siting missions has continued to increase to meet the needs of Member States introducing or expanding their nuclear power programs.

The IAEA continues to carry out extensive programs in nuclear safety, radiological safety waste management, research and environmental protection studies. During the calendar year it sponsored numerous regional meetings and symposia and has sent health and safety missions to countries seeking advice on particular problem areas. In 1975 the IAEA held two important symposia in the Unites States: (1) "International Symposium on Biological Effects of Low Level Radiation Pertinent to Protection of Man and his Environment," Chicago, Illinois, 3–7 November 1975, cosponsored by the World Health Organization; and (2) "International Symposium on Transuranium Nuclides in the Environment," San Francisco, California, 17–21 November 1975, cosponsored by the U.S. ERDA.

The IAEA also has a very active program of Safeguards in Peaceful Nuclear Activities. On 30 June 1975, 43 safeguards agreements with non-nuclear-weapon States party to Non Proliferation Treaty (NPT) were in force; 22 of these agreements were with States that have significant nuclear activities. Furthermore, safeguards were also being applied under then project agreements and either unilateral submission agreements. All of the latter 38 agreements provide for the application of safeguards under the Agency's Safeguards System.

In particular, during the period covered by the Annual Report the Board approved:

(a) In connection with NPT, safeguards agreements with Afghanistan, Ethiopia, Gabon, Japan, Sudan, Sweden and Tonga:

(b) In connection with both NPT and the Treaty for the Prohibition of Nuclear Weapons in Latin American (Tlatelolco Treaty), safeguards agreements with El Salvador and Honduras;

(c) A Safeguards Transfer Agreement between the IAEA, Israel and the United States of America:

(d) An agreement with Argentina for the application of safeguards to the Embalse Power Reactor Facility; and

(e) Two agreements with Spain and Switzerland respectively for the application of safeguards to nuclear material.

The IAEA has continued to standardize procedures for applying safeguards, particularly under NPT. It is reviewing existing Subsidiary Arrangements and "Facility Attachments" in the light of experience and applying this experience in connection with newly concluded agreements. Work has also started on standardizing the implementation of safeguards outside the framework of NPT.

A list of nuclear installations under IAEA safeguards or containing material safeguarded under arrangements approved by the Board is shown in the following breakdown on 30 June 1975 as compared to 30 June 1974:

Facilities

	NPT		Non-NPT	
	20 June 1974	30 June 1975	30 June 1974	30 June 1975
Nuclear Power Stations	12	17	24	30
Other Reactors	45	55	65	60
Conversion Plants, Fabrication Plants, and Fuel Reprocessing Plants	7	9	19	20
Other Separate Accountability Areas	28	86	88	109

The IAEA's records showed the following quantities of nuclear material to be under its safeguards:

	1969	1970	1971	1972	1973	1974
Plutonium (kg)	824	770	1,726	2,900	4,730	6,300
Enriched uranium						
(a) Total element (tons)	-	243	522	1,178	1,865	2,305
(b) Fissile content (tons)	4.6	6.1	11.2	26.0	43.0	53.0
Source material (tons)	1,070	1,146	1,200	2,145	3,370	3,910

During the year 1 July 1974–30 June 1975, the IAEA carried out 502 inspections in 37 nations (190 in connection with NPT), compared with 434 inspections (147 in connection with NPT) in 40 nations during the preceding year. Of the 502 inspections, 178 were made of power plants, 97 of bulk fuel fabrication plants and 227 of other facilities including research reactors.

NRC participated with the Department of State, Arms Control and Disarmament Agency and ERDA in (1) continuing efforts to develop a U.S.-IAEA safeguards in the U.S., (2) preparation of a Presidential report to Congress outlining ways of strengthening IAEA safeguards through allocation of funds made available under the Foreign Assistance Act of 1974, and (3) a meeting with the Safeguards Policy Committee of the Atomic Industrial Forum to discuss the draft U.S.-IAEA Agreement and its anticipated impact on U.S. industry.

Under an anticipated U.S.-IAEA agreement, the international agency would implement IAEA safeguards controls at certain U.S. Nuclear facilities. Affected plants would be mainly commercial operations, defense-related facilities are exempt. The U.S. has volunteered to apply IAEA safeguards control to domestic operations to demonstrate willingness to accept the same controls that nonnuclear-weapons countries are obliged to accept under the Treaty on the Non-Proliferation of Nuclear Weapons. The purpose of the IAEA safeguards program is timely detection of the diversion of significant quantities of nuclear material or facilities from peaceful uses to weapons use, and deterrence of such diversion by the risk of early detection. The U.S.-IAEA Safeguards Agreement is expected to be approved in 1976. NRC will be the primary contact with IAEA for licensed activities.

During the year, NRC contributed substantial support to the IAEA's intensified program for the collation and preparation of internationally acceptable codes and guides on the siting, safety, and reliability of nuclear power plants. In addition, NRC furnished IAES with a large number of U.S. nuclear safety documents to be used as models and examples for international safety codes and guides.

NRC experts participated in other IAEA activities, including efforts to strengthen international safeguards procedures and update recommendations to member countries on the protection of nuclear facilities and materials from terrorist attacks.

In 1975, NRC also supported IAEA training activities, especially those directed towards training technical and administrative manpower in developing countries which are planning or constructing their first nuclear power plants. In April and May 1975, NRC hosted and co-sponsored with IAEA a three-week course on the principles and techniques of regulating nuclear power for public health, safety, and environmental protection. Thirty-one foreign nuclear safety officials attended the course. NRC also prepared the regulatory/safety aspects of a syllabus for a 15-week course on nuclear-power-project planning and implementation to be held at ERDA's Argonne National Laboratory twice during 1976.

NUCLEAR ENERGY AGENCY (NEA) OF THE ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD)

The NEA acts as a service institution to the member nations for meeting the technical and technological requirements for nuclear power development within those countries. It provides activity reports on a quarterly basis; the most recent one available at this time is the "Third Activity Report, 1974," published in 1975.

NEA, on its own behalf, or in cooperation with the IAEA, WHO and FAO has held several symposia and meetings in the radiation protection area. For example, NEA convened a "Seminar on the Application of the Recommendations of the International Commission on Radiological Protection," in Paris, France, 5–7 March 1975.

The NEA has had a very active program in the waste management field, and has for several years been responsible for the international surveillance and control of a series of solid low-activity waste disposal operations at sea. During 1974 some 2,300 tons of waste incorporated in concrete or bitumen, and contained in some 4,000 metal drums was disposed of in the northeastern Atlantic Ocean. These wastes came from nuclear energy establishments in the Netherlands, Switzerland and the United Kingdom, and had a total activity of approximately 416 curies of alpha, 6,000 curies of beta-gamma, and 95,000 curies of low-energy beta in the form of tritium-contaminated wastes, most of which had been accumulated over several years. The ocean depth in the dumping area is some 4.5 km. A similar disposal operation was conducted in June 1975 in the same ocean site with containerized wastes from Belgium, The Netherlands, Switzerland and the United Kingdom. In this operation approximately 4,450 tons were disposed of and consisted of about 766 curies of alpha activity, 27,680 curies of beta-gamma, and 29,690 curies of tritium contaminated waste.

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP)

In 1975 the ICRP published ICRP Publication 23, "Report of the Task Group on Reference Man." This report is the culmination of effort started in 1973 by ICRP Committee II when it requested the Commission to establish Task Groups for the revision and extension of the standard man concept.

Estimates of dose equivalent resulting from human exposure to radionuclides that may enter the body depend upon many characteristics which must be indicated clearly if the ICRP recommendations on dose commitment, body burden, and MPC's are to be applied correctly. For this reason the Commission's recommendations relating to dose equivalent from internally deposited emitters have been specified in terms of a "Reference Man" whose characteristics, so far as relevant to the Commission's recommendations, are carefully specified. Also because of the increased emphasis on exposure of the population, it was desirable that the specifications of the previous "Standard Man" be reviewed and revised to take account of present needs for evaluation of exposure to radiation.

ICRP Report 23 "Reference Man" fulfills the charter given to the Task Group and will be as useful in meeting the needs of the health physicist now as was the "Standard Man" of 15 years ago.

THE UNITED NATIONS ENVIRONMENTAL PROGRAM (UNEP)

The UNEP continues its interests in supporting standards development, monitoring and assessment of potential environmental radiation hazards, and waste management. The Fund of UNEP has provided support for; ocean monitoring by the IAEA Marine Radioactivity Laboratory in Monaco; for various training programs; for updating radiation protection standards and recommendations by the International Commission on Radiological Protection; and an International Atomic Energy Agency program to study nuclear waste management problems. In addition, UNEP is supporting the WHO in developing health criteria for assessment of ultra-violet radiation exposure; and criteria documents for selected radionuclides, in cooperation with UNSCEAR, IAEA and WHO.

AGREEMENT BETWEEN CANADA AND THE UNITED STATES ON GREAT LAKES WATER QUALITY

During 1975 a team of technical experts representing National, State and Provincial governments of Canada and the U.S. completed a report entitled "Refined Radioactivity Objective for the Great Lakes Water Quality Agreement." U.S. participation came from EPA, NRC and the States of Pennsylvania, New York and Minnesota.

The report represents the joint recommendations of the U.S. and Canadian advisory groups on a radioactivity objective to preserve the quality of the Great Lakes. The objective is in terms of a dose equivalent to ICRP Reference Man from a standard annual intake of the Great Lakes water. The recommended objective for the general water quality in the Great Lakes is that level of radioactivity which results in a whole body dose equivalent not exceeding one millirem. Release of radioactive materials shall be as low as reasonably achievable and controlled by specific actions at defined levels.

CENTER FOR STANDARDIZATION OF PROTECTION AGAINST NONIONIZING RADIATION

The United States Public Health Service, Bureau of Radiological Health has been designated as the World Health Organization (WHO) Collaborating Center for Standardization of Protection Against Nonionizing Radiation, and, concurrently, the Bureau Director has been appointed Principal Investigator and Head of the Center. The Center will assist WHO in (1) estimating present levels and trends of human exposure from nonionizing radiation, (2) promoting the establishment of instrument calibration and reference services in various countries, (3) establishing internationally acceptable nomenclature, definition of terms and quantities, and dosimetry methods, (4) training public health personnel, (5) alerting health officials to the need for establishing nonionizing radiation control programs, and (6) stimulating international research on biological effects and development of measuring instrumentation.

An information exchange program established between the Bureau of Radiological Health, FDA and the Canadian Department of National Health and Welfare's Health Protection Branch provides a mechanism for the communication of information of mutual interest between the two health agencies which have major responsibility for controlling radiation emission and human exposure from electronic products in the United States and Canada. The thrust of the program is to share knowledge and experience in the conduct of national compliance programs.

Since there is no international commission or body to provide guidance and recommendations in the nonionizing radiation protection area, the International Radiation Protection Association (IRPA) has decided that as part of its activities it will serve as the international organization to stimulate research and exchange of scientific information in this field; and also sponsor or cosponsor seminars and symposia concerning all radiation protection aspects of nonionizing radiation.

In view of the lack of internationally accepted criteria on nonionizing radiation protection and of wide discrepancies of criteria adopted in various countries and by various schools of thought, the Executive Council of IRPA agreed to establish a Study Group. Its task is to prepare documents on criteria, standards and measurements for protection against nonionizing radiation and to prepare drafts of rules and procedures for a possible future international organization or commission to provide the necessary guidence on this subject. The Group is composed of experts from France, Poland, Denmark, USA, and the USSR, and it has met several times this past year. A report is in preparation by the Working Group and the IRPA Executive Council will discuss the report and present recommendations on the subject at the next IRPA International Congress in Paris, France, April 1977.

INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS (ICRU)

At its meeting in 1973, the ICRU discussed the important proposal that the special radiation units — curie, rad, rem, and roentgen — be abolished. After careful study, the Commission formulated the following statement on this topic.

Special Radiation Units

For a number of years, the ICRU has recommended the use of the International System (IS) of Units although it has continued to recognize and to use the special radiation units - rad, roentgen, curie and rem. Recently, the International Committee on Weights and Measures has listed the curie, rad and roentgen as temporary units.

One may infer that this committee visualizes the eventual replacement of these units by those of the international system. Of course, if this replacement takes place, there will be no modification of the current definitions of the now associated radiation quantities - activity, absorbed dose, and exposure.

Realizing that such a replacement might produce confusion or even possible mistakes in radiation therapy, the Secretary of the ICRU prepared a document on the problem and published it in pertinent professional journals. This document requested opinions and arguments for and against the abandonment of the special radiation units. Comments are still being received. The ICRU will formulate a recommendation on this matter at its July 1974 meeting. For the time being, new ICRU Reports will state numerical values of quantities in both IS and special units.

At its 1974 meeting, the Commission recognized that the adoption of the international system of units (IS) and the potential loss of the special radiation units raises severe problems. However, for a number of years the ICRU has recommended the use of the IS although it has continued to recognize the special radiation units. The problem was discussed in detail by the

Commission. To facilitate the possible introduction of the IS to radiology, a set of recommendations was agreed upon. Before dissemination of these recommendations, it was found necessary to refer some specific questions for consideration by the Consultative Committee on Units (CCU) of the International Committee of Weights and Measures at its meeting in September 1974.

During the 1975 meeting, the Commission received a report on the action taken by the General Conference of Weights and Measures to provide special names for two of the International System (IS) units for quantities of importance in radiation work — the gray, as the special name for the unit of absorbed dose, and the becquerel, as a special name of the unit for activity. Related to this action was Commission approval of the proposal that the gray be available for use as a special for the units of the quantities, absorbed dose, absorbed dose index, kerma, and specific energy. Related also to the action of the General Conference of Weights and Measures was the Commission's decision to undertake an examination of what should be done about a name for the units of dose equivalent and dose equivalent index. The Commission assigned preliminary work on this task to the Committee on Fundamental Quantities and Units. Also related to the availability of the new names for the special units of the quantities absorbed dose and activity was the Commission's decision that, in ICRU Reports to be produced in.the future, the new names for these two units would be employed, but that the values of the quantities in terms of the previously used specially named units would be set out parenthetically at the same time.

Thus the IS unit the joule per kilogram, when used for ionizing radiation (absorbed dose, kerma, specific energy imparted, etc.) is given the name "gray" with the symbol Gy; 1 Gy = 100rad = 1 Jkg-. The SI unit the reciprocal second (one per second) for activity is given the name "becquerel," symbol Bq; 1 Bq = 1s-1 = 2.703 x 10–11 Ci.

The ICRU now recommends that the special units the rad, the roentgen and the curie be gradually abandoned over a period of not less than about 10 years and replaced by the IS units the gray (Gy), the coulomb per kilogram (C kg-1) and the becquerel (Bq), respectively. It is desirable that preparatory steps be taken as soon as possible by various national and international bodies in order to facilitate a smooth, safe and efficient transition.

APPENDIX A
STATE LEGISLATION AND INITIATIVES AFFECTING NUCLEAR ENERGY

Radiation Control

Arkansas H-659. Establishes within Department of Health a statewide radiation control financial responsibility program. (Approved 3/12/75)

Illinois H-994. Amends current Radiation Protection Act to redefine "specific license" to include "radioactive," rather than "by-product, source or special nuclear" materials. (Approved 9/11/75)

Nevada A-761. Designates Division of Health as State radiation control agency; responsibilities include licensing of radioactive materials. (Approved 5/11/75)

New York S-6506. Amends general business law to prohibit possession or use of radioactive material without a license from the State's industrial commissioner. (Approved 8/9/75)

New York A-7896. Delegates State licensing authority of radioactive material to cities with population of 1 million or more. (Approved 8/9/75)

North Carolina. A broad revision of North Carolina's Radiation Protection Act. Creates Radiation Protection Commission. Authorizes environmental monitoring and surveillance programs around N-plants. (Ratified 6/23/75)

Oregon S-55. Empowers Health Division, Department of Human Resources, to take emergency action to protect the public against radiation. (Approved 6/3/75)

Virginia H-1694. Department of Health, as the State radiation control agency, to develop programs to deal with radiation emergencies. (Approved 3/22/75)

Power Plant Inspections

Colorado HB-1138. Expands powers of State radiation control agency to permit inspections of Federal installations without prior permission of appropriate Federal agency. (Approved 7/14/75)

Nuclear Studies

Connecticut H-7661. Creates Nuclear Power Evaluation Council to study and make recommendations by 2/15/76 concerning the extent to which Connecticut can regulate, supervise or monitor N-plants. (Approved 7/1/75)

Massachusetts H-5999. Directs a joint special committee to study nuclear power and its health and safety effects. (Adopted 6/10/75)

Montana S-374. Department of Natural Resources to study methods and effects of solution extraction of uranium, and propose appropriate legislation. (Approved 4/8/75)

Rhode Island S-180. Economic Development Corporation to study location and development of N-plants in Rhode Island. (Adopted 4/3/75)

Creation of Energy Agencies

Connecticut H-8554. Abolishes Energy Agency and consolidates planning and policy responsibilities into Department of Planning and Energy Policy. (Approved 6/30/75)

Florida SB-123. Florida Environmental Reorganization Act of 1975. (see "Nuclear Power Plant Siting") (Approved 5/22/75)

Kansas S-13. Creates Kansas Energy Office, including an Energy Advisory Council. (Approved 4/18/75)

New York A-8620. Originally intended to prohibit the construction of nuclear facilities, the bill, as enacted, served only to reconstitute the Atomic and Space Development Authority (ASDA) into an ERDA. (Approved 8/9/75)

North Carolina S-943. Creates Energy Policy Council, to serve as central energy policy planning body. (Ratified 6/26/75)

Oregon S-483. Creates Department of Energy and Energy Facility Siting Council. (See "Nuclear Power Plant Siting") (Approved 7/2/75)

Joint Agreements

Florida H-1329. Authorize publicly-and privately-owned electric utilities to jointly plan, finance, acquire, construct, own, manage, operate and utilize joint electric power supply projects. (Approved 6/25/75)

Nebraska L-104 and L-62. Permits public power districts to enter into joint agreements concerning electric generation or transmission facilities. (Approved 3/7/75)

North Carolina H-266. Authorizes municipalities to own and operate jointly electric generation and transmission facilities. (Ratified 5/1/75)

Utah H-111. Permits cities and regulated electric utilities to participate jointly in the development of power facilities. (Approved 3/17/75)

Referendum

Massachusetts H-6530. Provides that the following issue: "Shall a second nuclear power station be constructed within the town of Plymouth?" be placed on the next official ballot at the town meeting of Plymouth. Results are not binding. (Approved 8/28/75)

Legislative Control Over Nuclear Plants

Vermont H-127. Requires legislative approval for construction of nuclear plants. (Approved 4/3/75)

Licensing of Guards

Florida SB-245. Requires Department of State to license private guards. (Affects guards at N-plants) (Approved 6/27/75)

Transportation

Hawaii S-322. Relates to exterior markings on vehicles used to transport radioactive materials. (Approved 6/27/75)

Nuclear Power Plant Siting

Florida S-123. Creates Department of Environmental Regulation; transfers duties of Department of Pollution Control to DER, except for certain powers, relating to power plant siting, which are vested in the Governor and Cabinet. (Approved 5/22/75)

Minnesota S-1196. After 9/15/75, no large energy facility can be sited or constructed without a certificate of need. (Approved 5/17/75)

Montana H-581. A power or energy conversion facility may not be constructed without a certificate of environmental compatibility and public need. (Approved 4/21/75)

North Dakota S-2050. Requires site compatibility certificate for construction of a power plant. (Approved 4/9/75)

Oregon AJR-31. Abolishes Nuclear and Thermal Energy Council and transfers its functions to Energy Facility Siting Council. (Approved 7/2/75)

Wisconsin AB-463. Comprehensive siting bill, with siting authority vested in the Public Service Commission. (Approved 9/24/75)

Wyoming H-125. Industrial Siting Council permit required for construction of power plant. (Approved 3/8/75)

Disposal of Nuclear Wastes

Nevada AJR-15. Urges ERDA to choose Nevada Test Site for disposal of nuclear wastes. (Adopted 5/16/75)

Oregon S-163. Authorizes Department of Environmental Quality to establish and operate site(s) for disposal of environmentally hazardous wastes. (Approved 6/30/75)

Miscellaneous

North Carolina S-420. Establishes policy to govern expansion of electric utility facilities. (Ratified 6/24/75)

Oregon H-2629. Permits holder of a nuclear plant construction permit to prepay local taxes. (Approved 7/2/75)

Antinuclear Initiatives

During the year various organizations within the States have called for moratoria on the construction and operation of nuclear power plants. The U.S. Nuclear Regulatory Commission has compiled a listing of such activities and the status of the initiatives within the States is listed below (as of February 1976).

State	*Status of Initiative*
Arizona	– Initiative drive launched 12/19/75—55,220 signatures required by 7/9/76. (For Nov. ballot)
Arkansas	– Targeted by Critical Mass '75 for an initiative, but no evidence of activity to launch a drive.
California	– *Has qualified for June 8 ballot.* Secured 397,556 signatures (85,000 more than required). Legislative committee hearings held by Assemblyman Charles Warren and Senator Alfred Alquist. – Second initiative, to render above measure null and void, being circulated to collect 312,404 signatures by 3/17/76. (For Nov. ballot)
Colorado	– Drive launched 11/3/74—63,040 signatures required by 4/3/76. Over 50,000 collected as of 1/15/76. (For Nov. ballot)
Idaho	– Signature drive expected to begin soon.
Iowa	– Iowa does not allow initiatives; however, plans are being made for recall elections against State officials who support nuclear power.
Kansas	– (Same as Iowa)
Maine	– Drive launched Sept. 1975 for some 45,000 signatures; reported to be well on the way. Petition to be presented to Legislature in Jan. 1977; if rejected, it will become a ballot issue in Nov. 1977.

Massachusetts	– Failed to collect 56,000 valid signatures, but will present those that were obtained to the Legislature in attempt to influence legislation. Next opportunity for ballot – fall 1978.
Michigan	– Michigan PIRC expects to start campaign about March to collect 212,000 signatures. (For Nov. ballot)
Mississippi	– Rumored that signature collecting will start soon.
Montana	– Drive launched 10/1/75—16,000 signatures required by July. (For Nov. ballot)
Nebraska	– People's Lobby active but no evidence of drive.
Nevada	– If California initiative succeeds, similar drive possible in Nevada. Environmentalists opposing nuclear waste storage.
North Dakota	– Drive launched in January—10,000 signatures required by 8/8/76. (For Nov. ballot)
Ohio	– Initiative petition for constitutional amendment to require legislative approval for construction of nuclear plants submitted to State attorney general in January for approval of wording. Approx. 307,000 signatures required. (For Nov. ballot)
Oklahoma	– Drive to start March 1 for 65,000 signatures by 6/1/76. (For Nov. ballot)
Oregon	– *Has qualified for November 2 ballot.* More than 46,235 signatures obtained; however, public seems confused, e.g., a recent poll showed 53% favor initiative, 54% oppose nuclear moratorium, 72% oppose nuclear power ban, and 66% approve of Trojan nuclear plant.
	– Second initiative being considered – to prohibit operation of Trojan.
South Dakota	– Petition being withdrawn in favor of moratorium legislation.
Utah	– Signature collecting to start soon.
Washington	– Petition filed with Secretary of State February 3. Would require 118,000 signatures. (For Nov. ballot)

APPENDIX B
LIST OF RADIATION PROTECTION PUBLICATIONS – 1975

EPA PUBLICATIONS

EPA TECHNICAL REPORTS

EPA-520/1–75–001	Manual of Protective Action Guides & Protective Actions for Nuclear Incidents
EPA-520/3–75–003	Environmental Analysis of a Generic Fuel Reprocessing Facility
EPA-520/3–75–006	Significant Actinides in the LWR & LMFBR Nuclear Fuel Cycles
EPA-520/7–75–007	National Radiation Protection Program Strategy
EPA-520/6–75–010	Gamma Radiation Surveys and Inactive Uranium Mill Sites
EPA-520/4–75–011	Radionuclide Transport in the Great Lakes
EPA-520/3–75–012	Reactor Safety (WASH-1400): A Review of the Draft Report
EPA-520/6–75–013	Ground Water Quality Impacts of Uranium Mining & Milling in the Grants Mineral Belt
EPA-520/7–75–014	EPA Review of Radiation Protection Activities-1974
EPA-520/3–75–015	Risk Assessment of Storage & Transportation of Liquified Natural Gas & LP-Gas
EPA-520/3–75–016	The Consequence & Frequency of Selected Man-Originated Accident Events
EPA-520/5–75–018	16N Skyshine Survey at a #2400 MW(+) power plant
EPA-520/3–75–019	Radionuclide production, transport, and release from normal operation of liquid-metal-cooled Fast Breeder Reactors
EPA-520/4–75–020	Nuclear Medicine Environmental Discharge Measurement
EPA-520/3–75–021	Preliminary data on the occurrence of trans-uranium nuclides in the environment at the radioactive waste burial site, Maxey Flats, Kentucky
680/1–75–001	1FA082 Synergistic Effect of Polonium-210 and Cigarette Smoke in Rats
680/4–75–001	IHA325 Handbook of Radiochemical Analytical Methods.
680/4–75–002a	IHA327 Radioactivity Standards Distribution Program-1975

680/4–75–002b	1HA327 Environmental Radioactivity Laboratory Inter-Comparison Studies Program-1975
680/4–75–005	1HA327 Tentative Reference Method for the Measurement of Gross Alpha and Gross Beta Radioactivities in Environmental Waters

EPA TECHNICAL NOTES

EPA 906/9–002	Water Quality Impacts of Uranium Mining and Milling Activities in the Grants Mineral Belt, New Mexico
ORP/CSD-75–3	Radioactivity distribution in phosphate products, by-products, effluents, and wastes August 1975
ORP/CSD-75–4	Preliminary findings radon daughter levels in structures constructed on reclaimed Florida phosphate land September 1975
ORP/EAD-75–1	"An Analysis of Broadcast Radiation Levels in Hawaii August 1975
ORP/LV-75–1	Radioactivity in Construction Materials—A Literature Review and Bibliography
ORP/LV-75–2	Radiation Survey of Dwellings in Cane Valley, Arizona and Utah, for Use of Uranium Mill Tailings
ORP/LV-75–4	Summary of Ground-Water Quality Impacts of Uranium Mining and Milling in the Grants Mineral Belt, New Mexico
ORP/LV-75–5	Gamma Radiation Surveys at Inactive Uranium Mill Sites
ORP/LV-75–6	Individual and Population Doses for 1972 Discharges from the Ginna Nuclear Power Plant, Unit Number One
ORP/LV-75–7(A)	Radon Exhalation from Uranium Mill Tailings Piles—Description and Verification of the Measurement Method

EPA AUTHORED REPORTS

J.S. Ali: A Versatile Temperature Controlled Exposure Chamber for Microwave Bioeffects Research. IEEE Trans. Biomed. Eng. *BME-22*:76–77 (1975).

J.W. Allis, C.M. Weil, and D.E. Janes: A Crossed-Beam Apparatus for Simultaneous Spectrophotometric Observation and Microwave Exposure of Biochemical Samples. Rev. Sci. Instrument. *46*: 1344–1349 (1975).

C.F. Blackman, S.G. Benane, and J.S. Ali: Effects of Nonionizing Electromagnetic Radiation on Single-Cell Biologic Systems. Ann. N.Y. Acad. Sci. *247*: 352–366 (1975).

S.J. Bursian, D.F. Cahill, J.W. Laskey, and L.N. Parker: Some Aspects of Brain Neurochemistry After Intrauterine Exposure to Tritium. Int. J. Rad. Biol. *27*: 455–461 (1975).

D.F. Cahill, J.F. Wright, J.H. Godbold, J.M. Ward, J.W. Laskey, and E.A. Tompkins: Neoplastic and Life-Span Effects of Chronic Exposure to Tritium I. Effects on Adult Rats Exposed During Pregnancy. J. Natl. Cancer Inst. *55*: 371–374 (1975).

D.F. Cahill, J.F. Wright, J.H. Godbold, J.M. Ward, J.W. Laskey, and E.A. Tompkins: Neoplastic and Life-Span Effects of Chronic Exposure to Tritium II. Rats Exposed in Utero. J. Natl. Cancer Inst. *55*: 1165–1169 (1975).

J.A. Elder and J.S. Allis: The Effects of Microwaves (2450 MHz) on Isolated Rat Liver Mitochondria. Ann. N.Y. Acad. Sci. *247*: 251–262 (1975).

D.E. Janes, N.N. Handin, T.W. Athey, and R.A. Tell, "EPA Nonionizing Radiation Measurements Program," in Summary of Electrogagnetic Radiation Management Advisory Council (ERMAC) Work Session and Measurement of Environmental Levels of Nonionizing EM Radiation Office of Telecommunications Policy, Washington, D.C. (February 1975).

D.E. Janes: "Electric Effects of Extra-High Voltage and Ultrahigh Voltage Transmission Lines," Westinghouse International School for Environmental Management, Colorado State University, July 1975.

W.P. Kirk, P.W. Parrish and D.A. Morken: In Vivo Solubility of ^{85}Kr in Guinea Pig Tissues. Health Phys. *28*: 249–261 (1975).

W.P. Kirk and D.A. Morken: In Vivo Kinetic Behavior and Whole Body Partition Coefficients for ^{85}Kr in Guinea Pigs. Health Phys. *28*: 263–273 (1975).

W.P. Kirk, B.F. Rehnberg, and D.A. Morken: Acute Lethality in Guinea Pigs Following Respiratory Expousre to ^{85}Kr. Health Phys. *28*: 275–284 (1975).

W.P. Kirk: Behavior of ^{85}Kr in Animals. In *Noble Gases*, A.A. Moghissi and R.E. Stanley, Eds., Messenger Graphics, Phoenix (1975).

R.A. Tell and D.E. Janes: "Broadcast Radiation: A Second Look," presented at the 1975 U.S. National Committee of the International Radio Science Union (URSI) Meeting, 20–23 October 1975, Boulder, CO. (To be published in the conference proceedings.)

T.R. Ward, J.W. Allis, and J.A. Elder: Measure of Enzymatic Activity Coincident with 2450 MHz Microwave Exposure. J. Microwave Power *10*: 315–320 (1975).

C.M. Weil: Absorption Characteristics of Multi-Layered Sphere Models Exposed to UHF-Microwave Radiation. IEEE Trans. Biomed. Eng. *BME-22*: 468–477 (1975).

EPA PUBLIC HEARINGS

Plutonium

Vol I	Dec 10–11, 1974	April 1975
Vol II	Jan 10, 1975	July 1975
Vol III	Additional Materials Received	1975

ENVIRONMENTAL RADIATION DATA

EPA, EERF, Montgomery, Alabama

Report 1	June 1975 (January, February and March Data)
Report 2	September 1975 (April, May, and June Data)
Report 3	January 1976 (July, August and September Data)
Report 4	April 1976 (October, November and December Data)

BRH PUBLICATIONS

BRH TECHNICAL REPORTS

FDA 75–8007	A Standard Technique for Estimating Patient Exposure from Photofluorographic X-Ray Machines (GPO 017–015–00086–9, $0.70) (PB 244 738/AS, mf only).
FDA 75–8020	Automation and Scheduling and File Room Functions of a Diagnostic Radiology Department, Volume I (GPO 017–015–00082–6, $2.35) (PB 241 975/AS, mf only).
FDA 75–8021	Automation and Scheduling and File Room Functions of a Diagnostic Radiology Department, Volume II (NTIS PB 242 508/AS, $13.00).
FDA 75–8022	The Survey of Medical Radium Installations in Wisconsin (GPO-017–015–00088–5, $0.85) (PB 245 682/AS, mf only).
FDA 75–8023	Progress in Radiation Protection 1974.
FDA 75–8024	Gonad Shielding in Diagnostic Radiology (GPO 017–015–00087–7, $0.50).
FDA 75–8025	Index to Selected Acoustic and Related References (PB 239–805/AS, $11.25).
FDA 75–8026	Preliminary Evaluation of Commercially Available Laser Protective Eyewear (PB 241 903/AS, $3.75).
FDA 75–8027	Radiological Health Training Resources 1975.
FDA 75–8028	Precise Microwave Power Density Calibration Method Using the Power Equation Techniques March 1975 (GPO 017–015–00084–2, $0.85) (PB 242 883/AS, mf only).
FDA 75–8029	BRH Regulatory Guidelines For Diagnostic X-Ray Systems.
FDA 75–8031	Measurements of the Radiation Emissions of the Nuva-Lite Dental Appliance (GPO 017–012–00228–5, $1.05) (PB 242 882/AS, mf only).

FDA 75–8032	Changes in Radiofrequency E-Field Strengths Within a Hospital During a 16-Month Period (GPO-017–012–00229–3, $1.05) (PB 244 737/ASm mf only).
FDA 75–8033	Legislative History of Radiation Control for Health and Safety Act of 1968 (GPO 017–015–00089–3, Volumes I and 2, $24.00).
FDA 76–8001	Public Health Implications of Radioluminous Materials (GPO 017–015–00090–7, $1.10).
FDA 75–8002	Assembler's Guide to Diagnostic X-Ray Equipment.
FDA 76–8003	Nationwide Evaluation of X-Ray Trends.
FDA 76–8004	Measurement of Power Density from Marine Radar (in preparation).
FDA 76–8005	Radiation Safety Handbook for Ionizing & Nonionizing Radiation.
FDA 76–8006	Directory of Personnel Responsible for Radiological Health Programs.
FDA 76–8007	Electronics in the Home.
FDA 76–8008	X Rays...How Safe?
FDA 76–8009	Federal/State Radiation Control Legislation 1974.
FDA 76–8010	CSU-PHS Collaborative Radiological Health Laboratory Annual Report 1974.
FDA 76–8011	Nashville Dental Project: An Educational Approach for Voluntary Improvement of Radiographic Practice.
FDA 76–8013	A Comparison of Instrument Performance in Measuring X-Ray Tube Current and mAs.
FDA 76–8014	Suggested Optimum Survey Procedures for Diagnostic X-Ray Equipment.
FDA 76–8015	A System for Estimation of Mean Active Bone Marrow Dose.
FDA 76–8016	A Study of Retakes in Radiology Departments of Two Large Hospitals.
FDA 76–8017	Report of State and Local Radiological Health Programs, Fiscal Year 1974.
FDA 76–8020	Medical X-Ray Photo-Optical Systems Evaluation.
FDA 76–8021	A Review of Biological Effects and Potential Risks Associated with Ultraviolet Radiation as Used in Dentistry.
FDA 76–8022	The Use of Iodine-125 for Interstitial Implants.

BRH ANNUAL REPORTS

1975 Annual Report	Administration of the Radiation Control for

Health and Safety Act of 1968 Public Law 90-602
April 1, 1976.

Seventh Annual National Conference on Radiation Control

ERDA PUBLICATIONS

ERDA TECHNICAL REPORTS

ERDA0010	Interagency Radiological Assistance Plan.
ERDA0017	Emergency Handling of Radiation Accident Cases. Physicians. Previously WASH 1321
ERDA0018	Emergency Handling of Radiation Accident Cases. Nurses. Previously WASH 1322
ERDA0019	Emergency Handling of Radiation Accident Cases. Hospital Administrators. Previously WASH 1323
ERDA0020	Emergenty Handling of Radiation Accident Cases. Ambulance-Rescue Squads. Previously WASH 1324
ERDA0021	Emergency Handling of Radiation Accident Cases. Police. Previously WASH 1325
ERDA0022	Emergency Handling of Radiation Accident Cases. Sheriffs. Previously WASH 1326
ERDA0027	Emergency Handling of Radiation Accident Cases. Firemen. Published as ERDA 76-23
ERDA0034	Radiological Resurvey of Food, Soil, Air and Groundwater at Bikini Atoll 1972.
ERDA0039	The 1974 Review of the Research Program of the Division of Controlled Thermonuclear Research.
ERDA0044	Peaceful Nuclear Explosions
ERDA0056	Status of Safety Technology for Radiological Consequence Assessment of Postulated Accidents in Liquid Metal Fast Breeder Reactors.
ERDA0060	Energy Research and Development Administration Radiological Assistance Plan.
ERDA0092	Proceedings of the Third Environmental Protection Conference, Chicago, Ill. September 23-26, 1975 CONF-750967 2 Vols.

NRC PUBLICATIONS

NUREG-75/001	"Summary of Radioactivity Released in Effluents from Nuclear Power Plants During 1973." Office of Operations Evaluations. Jan. 1975.
NUREG-75/021	"Detailed Measurement of ^{131}I in Air, Vegetation and Milk Around Three Operating Reactor Sites." Office of Inspection and Enforcement. Nuclear Regulatory Commission, Energy Research and Development Administration and the Environmental Protection Agency. Mar. 1975.
NUREG-75/032	"Occupational Radiation Exposure at Light-Water-Cooled Power Reactors, 1969–1974." Office of Nuclear Reactor Regulation (Technical Review). June 1975.
NUREG-75/038	"Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants." (Supp. 1 to WASH 1238) Office of Standards Development (Engineering Standards). Apr. 1975.
NUREG-75/064	"Doses from Radioactive Actinides Released in Liquid Effluents from Light-Water-Cooled Nuclear Power Reactors." Office of Nuclear Reactor Regulation (Technical Review). June 1975.
NUREG-75/068	"Proceedings of the 1975 Federal-State Conference, Proceedings on Power Plant Siting." Office of International and State Programs. July 1975.
NUREG-75/090	"Report to Congress on Abnormal Occurrences: January – June 1975." Office of Management Information and Program Control. Oct. 1975.
NUREG-75/108	"Seventh Annual Occupational Radiation Exposure Report for Certain NRC Licensees – 1974." Office of Nuclear Reactor Regulation (Technical Review). Oct. 1975.
NUREG-75/111	(Reprint of WASH 1293). "Guide and Checklist for Development and Evaluation of State and Local Government Radiological Emergency Response Plans in Support of Fixed Nuclear Facilities." Office of International and State Programs. Oct. 1975.

NRC REGULATORY GUIDES

Regulatory Guide 4.1	(Revision 1) "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants."
Regulatory Guide 7.3	"Procedures for Picking Up and Receiving Packages of Radioactive Materials."
Regulatory Guide 7.4	"Leakage Tests on Packages for Shipment of Radioactive Materials."
Regulatory Guide 7.5	"Administrative Guide for Obtaining Exemptions from Certain NRC Requirements Over Radioactive Material Shipments."
Regulatory Guide 8.8	(Revision 1) "Information Relevant to Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable."

Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure."

Regulatory Guide 8.13 (Revision 1) "Instruction Concerning Prenatal Radiation Exposure."

NUCLEAR SCIENCE ABSTRACTS

Ballou, J.E. and G.E. Dagel, "Long Term Effects of Inhaled Pu (NO3)4 and Fs (NO3)3 in Rats."

Cheng, C.H., K.Y. Liu, C.T. Yung and P.S. Weng, "Implementation of a Nationwide Program on Health and Safety of Medical X-Rays."

Dean, P.N., R.V. Griffith and A.L. Anderson, "Design Criteria for Phantoms for Calibration of External Detectors for the In-Vivo Assay of Plutonium."

Failla, L. "Radiation Protection Concepts: Proposal for a New Criterion."

Gamertsfeler, C.C., "Other Considerations in Establishing Standards."

Hendee, W.R. and E.L. Chaney, "Diagnostic X-Ray Survey Procedures for Fluoroscopic Installations."

Jeiter, W., "Radiation Protection in Medicine." (In German)

Lingjaerde, R., "Ionizing Radiation: Present Valves Too Strict." (In Norwegian)

Linsley, G.S., "Radioactive Relics."

Lovins, A.B. and W.C. Patterson, "Plutonium Particles: Some Like Them Hot."

Mummery, P.W., "Health and Safety and the Nuclear Industry."

Norwood, W.D., "Health Protection of Radiation Workers."

Odor, D.L., "Health Physicist and Nuclear Power Plant."

Park, J.F., R.L. Buschbom, D.L. Catt, D.K. Craig, G.E. Dagle, P.L. Hackett, G.J. Powers, H.A. Ragan, C.R. Watson, "Dose Effect Studies with Inhaled ^{239}PuO2 in Beagles."

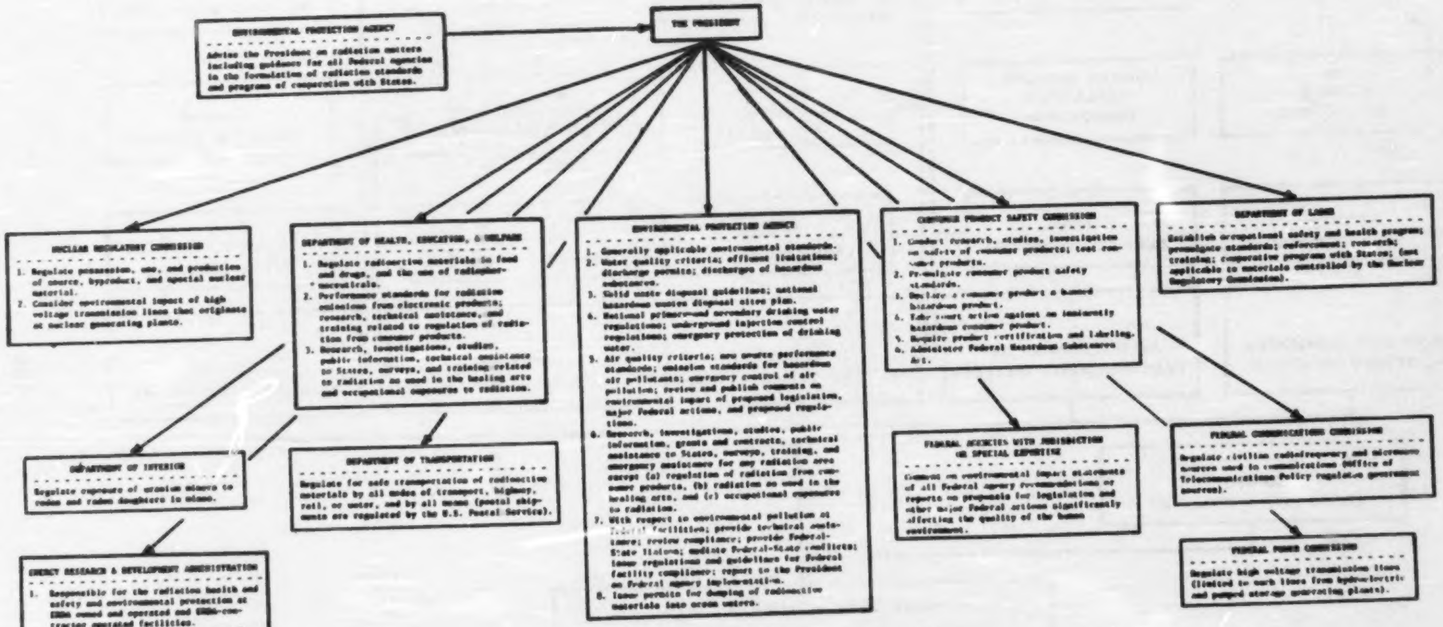
Ryer, F.H., "New Health and Safety Act as it Relates to Occupational Radiation Exposure."

APPENDIX C

Federal agency organizational charts depicting only those respective components which engage in radiation protection activities are as follows:

Figure 1	Summary Diagram of Major Federal Radiation Protection Functions
Figure 2	EPA
Figure 3	ERDA
Figure 4	DHEW-FDA-BRH
Figure 5	NRC

SUMMARY DIAGRAM OF MAJOR FEDERAL RADIATION PROTECTION FUNCTIONS



ENVIRONMENTAL PROTECTION AGENCY

Advise the President on radiation matters including guidance for all Federal agencies in the formulation of radiation standards and programs of cooperation with States.

NUCLEAR REGULATORY COMMISSION

1. Regulate possession, use, and production of source, byproduct, and special nuclear material.
2. Consider environmental impact of high voltage transmission lines that originate at nuclear generating plants.

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

1. Regulate radioactive materials in food and drugs, and the use of radiopharmaceuticals.
2. Performance standards for radiation emissions from electronic products; research, technical assistance, and training related to regulation of radiation from consumer products.
3. Research, investigations, studies, public information, technical assistance to States, surveys, and training related to radiation as used in the healing arts and occupational exposures to radiation.

ENVIRONMENTAL PROTECTION AGENCY

1. Generally applicable environmental standards.
2. Water quality criteria; effluent limitations; discharge permits; discharges of hazardous substances.
3. Solid waste disposal guidelines; national hazardous wastes disposal sites plan.
4. National primary and secondary drinking water regulations; underground injection control regulations; emergency protection of drinking water.
5. Air quality criteria; new source performance standards; emission standards for hazardous air pollutants; emergency control of air pollution; review and publish comments on environmental impact of proposed legislation, major Federal actions, and proposed regulations.
6. Research, investigations, studies, public information, grants and contracts, technical assistance to States, surveys, training, and emergency assistance for any radiation area except (a) regulation of radiation from consumer products, (b) radiation as used in the healing arts, and (c) occupational exposures to radiation.
7. With respect to environmental pollution at Federal facilities; provide technical assistance; review compliance; provide Federal-State liaison; mediate Federal-State conflicts; issue regulations and guidelines for Federal facility compliance; report to the President on Federal agency implementation.
8. Issue permits for dumping of radioactive materials into ocean waters.

CONSUMER PRODUCT SAFETY COMMISSION

1. Conduct research, studies, investigation on safety of consumer products; test consumer products.
2. Promulgate consumer product safety standards.
3. Declare a consumer product a banned hazardous product.
4. Take court action against an imminently hazardous consumer product.
5. Require product certification and labeling.
6. Administer Federal Hazardous Substances Act.

DEPARTMENT OF LABOR

Establish occupational safety and health program; promulgate standards; enforcement; research; training; cooperative programs with States; (not applicable to materials controlled by the Nuclear Regulatory Commission).

DEPARTMENT OF INTERIOR

Regulate exposure of uranium miners to radon and radon daughters in mines.

DEPARTMENT OF TRANSPORTATION

Regulate for safe transportation of radioactive materials by all modes of transport, highway, rail, or water, and by all means (postal shipments are regulated by the U.S. Postal Service).

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION

1. Responsible for the radiation health and safety and environmental protection at ERDA owned and operated and ERDA-contractor operated facilities.
2. Engages in and supports environmental, biomedical, physical, and safety research related to the development of energy sources and utilization technologies.

FEDERAL AGENCIES WITH JURISDICTION OR SPECIAL EXPERTISE

Comment on environmental impact statements of all Federal agency recommendations or reports on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.

FEDERAL COMMUNICATIONS COMMISSION

Regulate civilian radiofrequency and microwave sources used in communications (Office of Telecommunications Policy regulates government sources).

FEDERAL POWER COMMISSION

Regulate high voltage transmission lines (limited to such lines from hydroelectric and pumped storage generating plants).

FIGURE 1

Reproduced from best available copy.

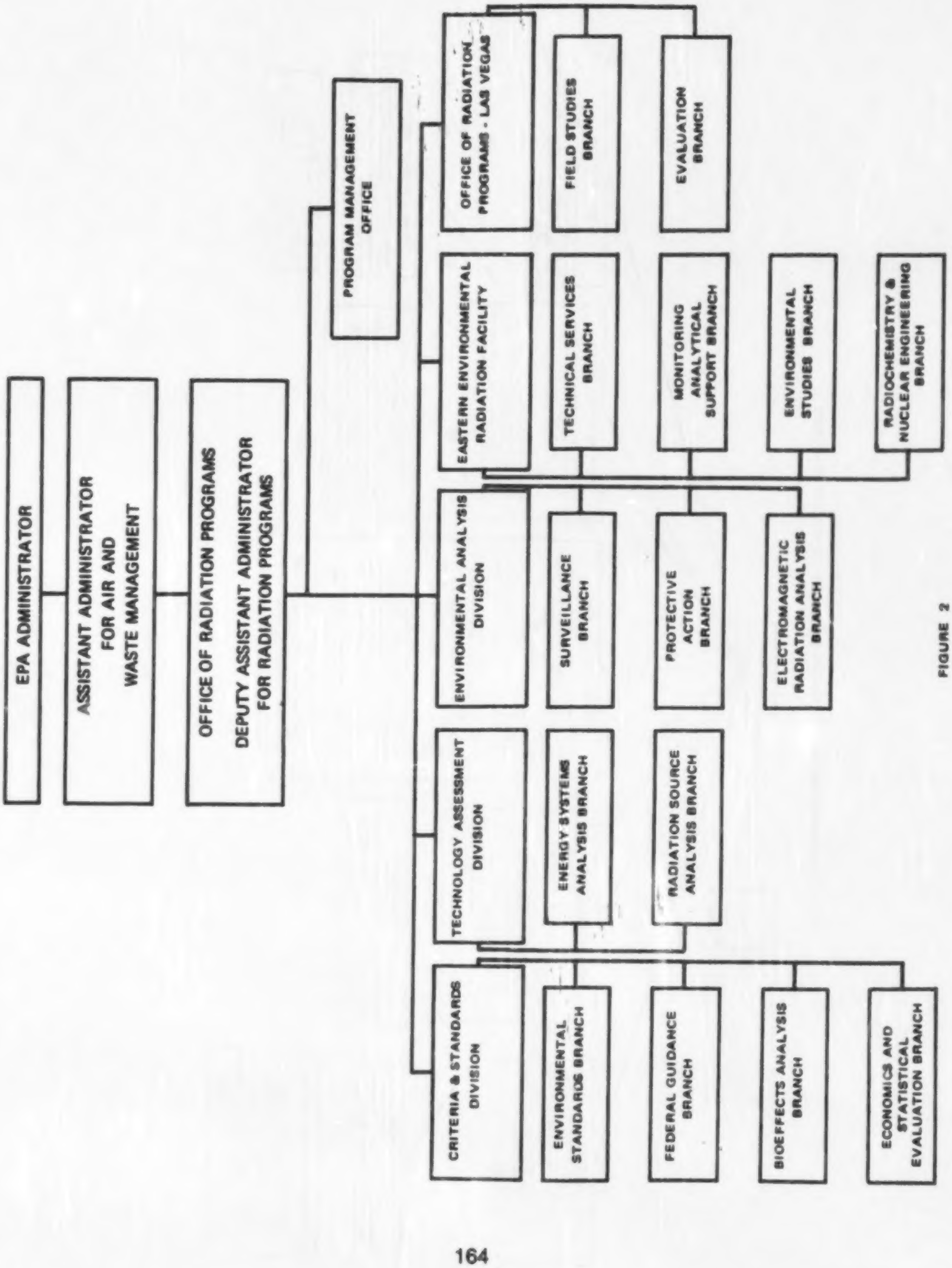

EPA ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR AIR AND WASTE MANAGEMENT
OFFICE OF RADIATION PROGRAMS
DEPUTY ASSISTANT ADMINISTRATOR FOR RADIATION PROGRAMS
PROGRAM MANAGEMENT OFFICE
CRITERIA & STANDARDS DIVISION
ENVIRONMENTAL STANDARDS BRANCH
FEDERAL GUIDANCE BRANCH
BIOEFFECTS ANALYSIS BRANCH
ECONOMICS AND STATISTICAL EVALUATION BRANCH
TECHNOLOGY ASSESSMENT DIVISION
ENERGY SYSTEMS ANALYSIS BRANCH
RADIATION SOURCE ANALYSIS BRANCH
ENVIRONMENTAL ANALYSIS DIVISION
SURVEILLANCE BRANCH
PROTECTIVE ACTION BRANCH
ELECTROMAGNETIC RADIATION ANALYSIS BRANCH
EASTERN ENVIRONMENTAL RADIATION FACILITY
TECHNICAL SERVICES BRANCH
MONITORING ANALYTICAL SUPPORT BRANCH
ENVIRONMENTAL STUDIES BRANCH
RADIOCHEMISTRY & NUCLEAR ENGINEERING BRANCH
OFFICE OF RADIATION PROGRAMS - LAS VEGAS
FIELD STUDIES BRANCH
EVALUATION BRANCH

FIGURE 2

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

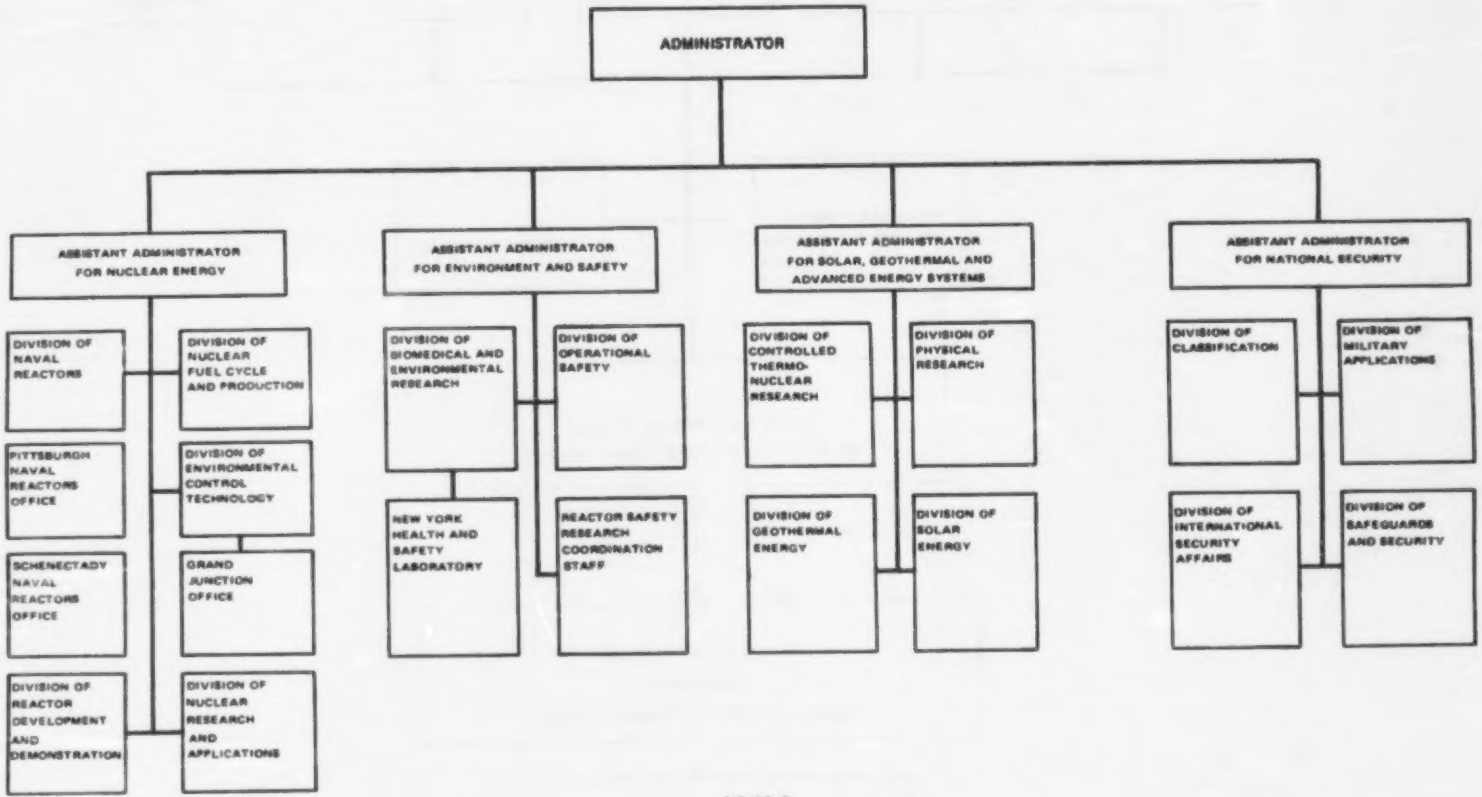

ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR NUCLEAR ENERGY
DIVISION OF NAVAL REACTORS
DIVISION OF NUCLEAR FUEL CYCLE AND PRODUCTION
PITTSBURGH NAVAL REACTORS OFFICE
DIVISION OF ENVIRONMENTAL CONTROL TECHNOLOGY
SCHENECTADY NAVAL REACTORS OFFICE
GRAND JUNCTION OFFICE
DIVISION OF REACTOR DEVELOPMENT AND DEMONSTRATION
DIVISION OF NUCLEAR RESEARCH AND APPLICATIONS
ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY
DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH
DIVISION OF OPERATIONAL SAFETY
NEW YORK HEALTH AND SAFETY LABORATORY
REACTOR SAFETY RESEARCH COORDINATION STAFF
ASSISTANT ADMINISTRATOR FOR SOLAR, GEOTHERMAL AND ADVANCED ENERGY SYSTEMS
DIVISION OF CONTROLLED THERMO-NUCLEAR RESEARCH
DIVISION OF PHYSICAL RESEARCH
DIVISION OF GEOTHERMAL ENERGY
DIVISION OF SOLAR ENERGY
ASSISTANT ADMINISTRATOR FOR NATIONAL SECURITY
DIVISION OF CLASSIFICATION
DIVISION OF MILITARY APPLICATIONS
DIVISION OF INTERNATIONAL SECURITY AFFAIRS
DIVISION OF SAFEGUARDS AND SECURITY

FIGURE 3

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

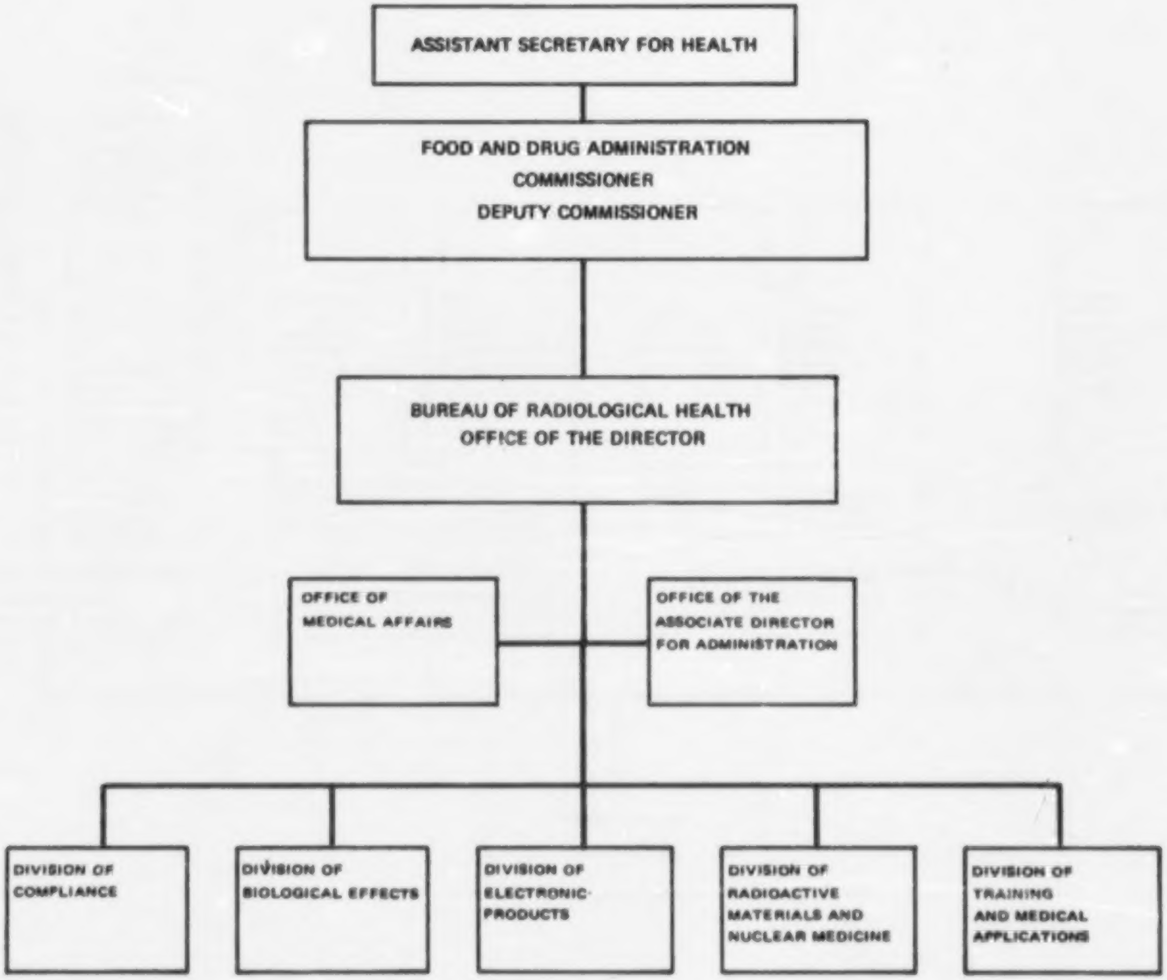

ASSISTANT SECRETARY FOR HEALTH
FOOD AND DRUG ADMINISTRATION
COMMISSIONER
DEPUTY COMMISSIONER
BUREAU OF RADIOLOGICAL HEALTH
OFFICE OF THE DIRECTOR
OFFICE OF MEDICAL AFFAIRS
OFFICE OF THE ASSOCIATE DIRECTOR FOR ADMINISTRATION
DIVISION OF COMPLIANCE
DIVISION OF BIOLOGICAL EFFECTS
DIVISION OF ELECTRONIC-PRODUCTS
DIVISION OF RADIOACTIVE MATERIALS AND NUCLEAR MEDICINE
DIVISION OF TRAINING AND MEDICAL APPLICATIONS

FIGURE 4

NUCLEAR REGULATORY COMMISSION

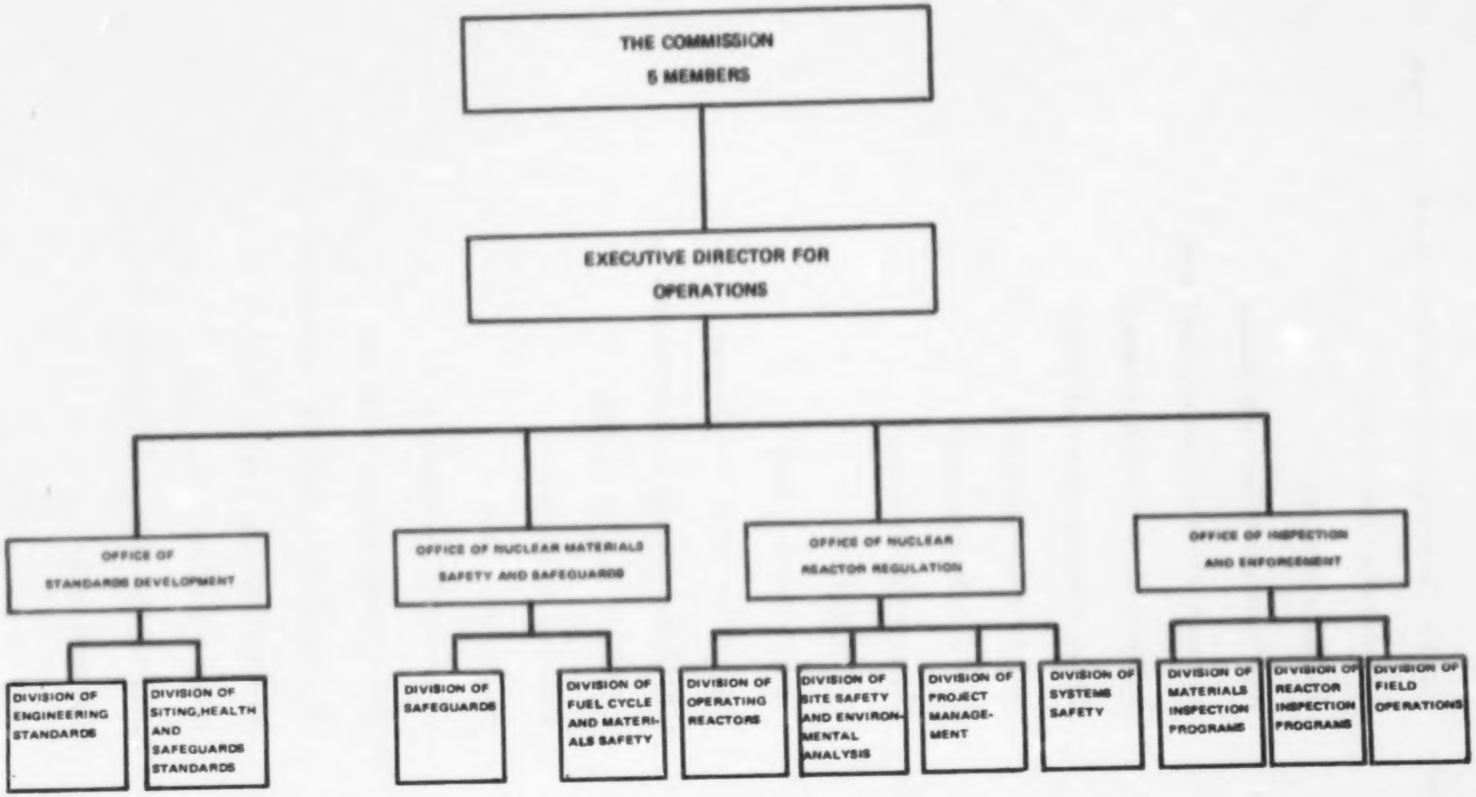

THE COMMISSION
5 MEMBERS
EXECUTIVE DIRECTOR FOR OPERATIONS
OFFICE OF STANDARDS DEVELOPMENT
DIVISION OF ENGINEERING STANDARDS
DIVISION OF SITING, HEALTH AND SAFEGUARDS STANDARDS
OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS
DIVISION OF SAFEGUARDS
DIVISION OF FUEL CYCLE AND MATERIALS SAFETY
OFFICE OF NUCLEAR REACTOR REGULATION
DIVISION OF OPERATING REACTORS
DIVISION OF SITE SAFETY AND ENVIRONMENTAL ANALYSIS
DIVISION OF PROJECT MANAGEMENT
DIVISION OF SYSTEMS SAFETY
OFFICE OF INSPECTION AND ENFORCEMENT
DIVISION OF MATERIALS INSPECTION PROGRAMS
DIVISION OF REACTOR INSPECTION PROGRAMS
DIVISION OF FIELD OPERATIONS

FIGURE 6

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
AM	Amplitude Modulation
ANSI	American National Standards Institute
ASNT	American Society for Nondestructive Testing
BEIR	Biological Effects of Ionizing Radiation
BRH	Bureau of Radiological Health, DHEW
CFR	Code of Federal Regulations
CIA	Central Intelligence Agency
COMM	Department of Commerce
CW	Continuous Wave
DAP	Diammonium Phosphate
DCPA	Defense Civil Preparedness Agency
DHEW	Department of Health, Education and Welfare
DNA	Defense Nuclear Agency, DOD
DOD	Department of Defense
DOL	Department of Labor
DOT	Department of Transportation
EAD	Environmental Analysis Division, ORP
ECAC	Electromagnetic Compatibility Analysis Center, DOD
EHF	Extremely High Frequency, 30–300 GHz
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency, 3–3000 Hz
EM	Electromagnetic

EMR	Electromagnetic Radiation
EMSL	Environmental Monitoring and Support Laboratory, DHEW
EPA	Environmental Protection Agency
ERAB	Electromagnetic Raidation Analysis Branch, ORP
ERAC	Electromagnetic Compatibility Analysis Center, DOD
ERAMS	Environmental Radiation Ambient Monitoring System
ERDA	Energy Research and Development Administration
ERMAC	Electromagnetic Radiation Management Advisory Council
FAA	Federal Aviation Agency
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FDA/BRH	Food and Drug Administration/Bureau of Radiological Health
FM	Frequency Modulation
FPC	Federal Power Commission
FR	Federal Register
FWPCA	Federal Water Pollution Control Act (of 1974)
GESMO	Generic Environmental Statement on Mixed Oxide Fuels
GHz	Gigahertz, 1,000,000,000 Hz (1,000 MHz)
GSA	General Services Administration
HF	High Frequency, 3–30 MHz
Hz	Hertz
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
IRAC	Interdepartment Radio Advisory Committee
ITS	Institute of Telecommunication Science, COMM
kV	Kilovolt (1,000 volts)

LF	Low Frequency, 30–300 kHz
LMFBR	Liquid Metal Fast Breeder Reactor
LWR	Light Water Reactor (or Light-Water-Cooled Reactor)
MAP	Monoammonium Phosphate
MF	Medium Frequency, 300–3,000 kHz
MHz	Megahertz, 1,000,000 Hz (1,000 hHz)
mrem	Millirems
mW	Milliwatt, 1/1,000 watt
MW	Microwave
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards, COMM
NDT	Nondestructive Testing
NEPA	National Environmental Protection Act
NEXT	Nationwide Evaluation of X-Ray Trends
NIEHS	National Institute of Environmental Health Sciences, DHEW
NIOSH	National Institute of Occupational Safety and Health
NRC	Nuclear Regulatory Commission
NRDC	National Resource Defense Council
NSF	National Science Foundation
ORD	Office of Research and Development, EPA
ORP	Office of Radiation Programs, EPA
ORP-LVF	Office of Radiation Programs-Las Vegas Facility
OSHA	Occupation Safety and Health Administration, DOL
OTP	Office of Telecommunications Policy
pCi	Pico Curies
PAG	Protective Action Guides

RF	Radio Frequency
SHF	Super High Frequency, 3–30 GHz (3,000–30,000 MHz)
TLD	Thermoluminescent Dosimeter
TSP	Triple Superphosphate
UHF	Ultra High Frequency, 300–3,000 MHz
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection
USIA	U.S. Information Agency
VA	Veterans Administration
VHF	Very High Frequency, 30–300 MHz
VLF	Very Low Frequency, 3–30 kHz
WHO	World Health Organization, United Nations

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